

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION of  
Inventor(s): Mills

App'n Ser. No.: 09/513,768

Filing Date: 02/25/2000

Title: ION CYCLOTRON POWER CONVERTER AND RADIO MICROWAVE  
GENERATOR



Group Art Unit: 2881

Examiner(s): Wells, Nikita

August 19, 2003

**REQUEST FOR CONTINUING EXAMINATION PURSUANT TO  
37 C.F.R. § 1.114, INCLUDING SUBMISSION OF: (1) RULE 132 DECLARATION  
AND NEW EXPERIMENTAL EVIDENCE; (2) INFORMATION DISCLOSURE  
STATEMENT; AND (3) REQUEST FOR FULL CONSIDERATION OF RESPONSE  
FILED JANUARY 29, 2003**

Commissioner for Patents  
P.O. Box 1450  
Alexandria, VA 22313-1450

Sir:

Applicant files this Request for Continued Examination (RCE) in this case pursuant to 37 C.F.R. § 1.114.

Reconsideration and allowance of the subject application are respectfully requested.

Claims 1-209 are pending in the application.

In view of Applicant's filing this RCE application, the finality of the July 29, 2002 Office Action, and Applicant's appeal from that Final Office Action, should be withdrawn so that the following submissions can be fully considered:

- (1) Response and extensive experimental evidence submitted on January 29, 2003;
- (2) new extensive experimental evidence as described below and Rule 132 Declaration certifying evidence that has not finished peer-review process; and

16  
Copy  
Paper #21

RECEIVED  
AUG 20 2003  
TECHNOLOGY CENTER 2880

(3) Information Disclosure Statement.

This RCE application is necessitated by the PTO's continuing failure to properly consider the extensive scientific evidence of record proving the existence of lower-energy hydrogen, i.e., "hydrinos," underlying his claimed invention. This failure resulted in the entry of a premature Final Rejection in this case.

**Renewed Request to Withdraw Finality  
of the July 29, 2002 Final Office Action**

As an initial matter, Applicant strongly objects to Examiner Wells' using the present May 7, 2003 Advisory Action to supply, in his words, "key analysis and discussion" that was missing from the July 29, 2002 Final Office Action rejecting claims 1-209. Because this supplementing of the substantive grounds of rejection was not done in response to any of Applicant's Rule 116 amendments, the finality of the Final Office Action should be withdrawn.<sup>1</sup> [See MPEP § 706.07]

Examiner Wells makes the case for withdrawing finality by quoting in his Advisory Action (at pp. 2-3) Applicant's prior objections to the obvious shortcomings of the Final Office Action:

In applying the present Section 101 rejection the Examiner . . . improperly presumes the utility of Applicant's invention to be per se incredible, while ignoring the vast majority of theoretical explanation and experimental evidence supporting that utility. For instance, the Examiner has not yet provided any explanation of how the extensive theory disclosed in the present specification is in error and why the supporting experimental evidence does not demonstrate the utility of what Applicant is claiming. Instead, the Examiner continues to violate Section 101 standards by merely concluding that "the invention is based upon assumptions that are contrary to basic, well established, laws of quantum physics and, therefore, is inoperative and lacks utility." [Final Office Action at p. 4]

<sup>1</sup> The only amendments submitted under Rule 116 were minor ones to claims 4-10, which in no way necessitated the extensive substantive grounds of rejection newly advanced by the Examiner. [See "Amendment Under Rule 116 and Response to Final Office Action," dated January 29, 2003, pp. 1-8] As indicated on page 8 of that Amendment, claim 4 was amended to remove an example of the electrical load. Claims 5-10 were amended to refer to the microwave power source, power converter, and radio and microwave generator of claim 1 to provide antecedent basis. None of these amendments were made to overcome prior art, to limit the claim scope in any way, or to add new matter.

Examiner Wells does not dispute the bases for these objections. In fact, the Examiner confirms on page 3 of his Advisory Action the substantive deficiencies of the Final Office Action by treating Applicant's objections as a "challenge" necessitating a substantive response:

Thus the applicant challenges the Examiner to provide an explanation of errors found in the extensive theory disclosed in the present specification and errors in the supporting experimental evidence. The Examiner's arguments are as follows:

Examiner Wells then proceeds to supply some, though not all, of the missing information complained of by Applicant, including what he describes as "key analysis and discussion provided in the [16-page] Appendix."<sup>2</sup> [Advisory Action at p. 5 (emphasis added)] While this key analysis and discussion lack merit, that does not excuse the fact that this information should have been presented earlier to give Applicant a fair opportunity to respond prior to final rejection.

Ironically, in his Rule 116 Amendment, Applicant also requested that the Examiner withdraw the finality of the July 29, 2002 Final Office Action for having delayed in supplying key information in that paper relating to the rejections of record, only to have that request ignored. [See Rule 116 Amendment at pp. 8-13] Specifically, Applicant noted that the Final Office Action began with the following summary:

[Applicant] made an in-depth analysis of the rebuttal of the rejection of the claims and pointed out the errors in the thinking of the Examiner as to the rejections in question.

\* \* \*

The Applicant argued that the theory is substantiated by compelling experimental evidence which confirms the existence of a lower-energy hydrogen as carried out and presented by the Applicant . . . . The Applicant construed that the Examiner did not analyze the experimental data as he mentioned . . . which is not the case. [Final Office Action at p. 2 (emphasis in original)]

---

<sup>2</sup> The failure of the newly presented Appendix to seriously analyze the bulk of Applicant's scientific data, and the lack of merit in the scant analysis that is provided, are discussed below.

Applicant's assumption, however, that the Examiner did not properly analyze the experimental data was based on the following quote from page 2 of the first Office Action, dated July 26, 2001:

The data presented in the Experimental section is not conclusive. Its analysis and any judgment upon its significance is outside the scope of the Examiner. [Emphasis added.]

[See January 28, 2002 Response at p. 3] Applicant interpreted that statement as an admission by the Examiner that he had failed to properly consider Applicant's experimental evidence supporting the existence of lower-energy hydrogen in rejecting the pending claims. Id.

Amazingly, Examiner Wells claimed that he "did scrutinize the data," but "found the compelling experimental evidence to be inconclusive as presented." [Final Office Action at p. 2 (emphasis in original)] Applicant found that statement somewhat surprising given the Examiner's admission that the significance of the scientific data was outside the scope of his understanding, as well as his failure to analyze or otherwise address the merits of data that had been submitted.

Instead, Examiner Wells merely commented on scientific data that was supposedly missing, which data would have presumably convinced him to consider allowing the claims:

It is the Examiner's opinion that the demonstration of the existence of a novel hydrogen species having lower energy states is best demonstrated by a shift in the Lyman series lines towards the far ultra-violet. This data should be compared to the regular hydrogen series. Unfortunately, this analysis and data is missing in the Applicant's experimental evidence presentation.<sup>3</sup> [Final Office Action at p. 2]

While appreciative of Examiner Wells' efforts to provide a road map for securing allowance of claims, Applicant could not understand why the Examiner's views on the spectroscopic data, which had served to advance prosecution of this application, had

<sup>3</sup> Applicant identified the data requested by Examiner Wells demonstrating the shift in the Lyman series lines towards the far ultra-violet for novel hydrogen species having lower-energy states, as compared to ordinary hydrogen series. [Rule 116 Amendment at pp. 15-17] Unbelievably, the "key analysis and discussion" supplied by the Examiner in his Advisory Action either ignores that data completely or provides unsupported conclusions. As discussed in more detail below, this latest action continues the PTO's pattern of giving Applicant false hope that his experimental evidence will be fairly evaluated and possibly lead to the allowance of claims when, in fact, allowance is not even an option.

                     ← *Damn Right!*

not been presented earlier in the first Office Action. [Rule 116 Amendment at pp. 9-10] Based on the Examiner's statement in that first Office Action that analysis of the data presented, and any judgment upon its significance, is "outside the scope of the Examiner," and his failure to identify any alleged deficiencies associated with that data, Applicant requested that the finality of the Final Office Action be withdrawn. Id. at p.10.

Incredibly, in his Advisory Action, Examiner Wells not only ignores that request, but then proceeds to partially explain for the very first time the missing reasoning behind the prior vague statements in his Final Office Action finding Applicant's "compelling experimental evidence to be inconclusive as presented." The fact that the Examiner does so by relying on self-described "key analysis and discussion" included in a 16-page Appendix written by a previously unknown Associate Examiner, Bernard Eng-Kie Souw,<sup>4</sup> confirms previously expressed concerns that Applicant has not been given a fair opportunity to address and overcome the final rejections of record.

Accordingly, Applicant renews his previous request to withdraw the finality of the July 29, 2002 Final Office Action. If this request is granted, as it should be, then the Examiner need not act on Applicant's Request for Continued Examination in this case, but rather, should treat this filing as a response to a non-final Office Action.

---

<sup>4</sup> Additional irregularities associated with the introduction of Examiner Souw into this case and his Appendix arguments are discussed below.



**Applicant Protests The PTO's Attack On the Credibility Of His  
Experimental Data Based On The False Premise That It Was Not Subject To  
"Appropriate Review" Or Published In "Scientifically Qualified" Journals**

Applicant turns now to the substantive analysis and discussion presented for the first time in Examiner Wells' Advisory Action in partial response to Applicant's demand that he supply his missing views on the experimental evidence of record. Applicant was disappointed by that response upon learning that the Examiner had summarily dismissed on highly questionable grounds the entirety of the published scientific data submitted in this case to support the existence of lower-energy hydrogen.

Based on this latest turn of events, Applicant suspects that the same anonymous group of PTO officials, i.e. "Secret Committee," has now taken steps similar to those documented in other BlackLight applications handled by Examiners Wayne Langel and Stephen Kalafut to ensure that allowance is not an option in this case. See, for example, the attached March 6, 2003 "Response" (Tab C) and May 1, 2003 "Supplemental Response" (Tab D) filed in BlackLight's copending App'n Ser. No. 09/110,678, which papers are incorporated herein by reference and to which a response is solicited. Applicant protests these arbitrary actions in the strongest terms possible and requests that the PTO reconsider its position.

To fully comprehend the arbitrariness of the PTO's unfair dismissal of Applicant's scientific data, it should first be noted that it was the Secret Committee that required Applicant, over his objections, to publish that data in peer-reviewed scientific journals. This requirement stemmed from an Interview held on February 21, 2001, during which Examiner Vasudevan Jagannathan refused to seriously consider the data presented at the Interview because it had not been subjected to the peer-review process required by most scientific journals prior to publication. For instance, Examiner Jagannathan considered Applicant's highly reliable spectroscopic data as nothing more than a "bunch of squiggly lines." [See attached March 6, 2003 "Response" filed in App'n Ser. No. 09/110,678, p. 7 (Tab C)]

Despite the fact that the PTO has never cited any authority to support its publication requirement, Applicant expended considerable effort—not to mention many millions of dollars—complying with it. Yet, now that Applicant has published his

experimental data in over 50 technical papers appearing in a number of respected scientific journals, with another 40-plus papers in press soon to follow, Applicant is advised for the first time, in an Advisory Action no less, that those efforts were for naught.

In summarily invalidating all of Applicant's published papers, the PTO improperly relies upon a false premise regarding the degree to which they were peer reviewed and the qualifications of the journals that published them:

→ [I]f one analyzes the status of the 80 technical papers submitted by the Applicant, NONE of Applicant's alleged "compelling" and "overwhelming" evidence of Applicant's lower-energy atomic hydrogen (the fictive "hydrino" atoms) are valid. Most of the papers have not yet been published in scientifically qualified journals with appropriate review process so that they are not yet credible. While others appeared as "Attachments" to main papers on pure experimental works, which do not rely on the "hydrino" as a fundamental basis (see Appendix for details). [Advisory Action at p. 3]

was true: The supposed non-credible journals the Examiner refers to include:

Electrochimica Acta;  
IEEE Transactions on Plasma Science;  
International Journal of Hydrogen Energy;  
Journal of Applied Physics;  
Journal of Molecular Structure; and  
New Journal of Physics.

→ Applicant is entitled to know in more detail the precise basis upon which the PTO has concluded that these journals are not credible.<sup>5</sup> More specifically, in evaluating technical papers submitted in support of patent applications, what standards does the PTO apply in deciding whether a particular journal is "scientifically qualified"? What standards are used to determine whether a journal has in place an "appropriate review process"?

<sup>5</sup> No doubt, the many patentees who have relied on scientific data published in these same esteemed journals to support patentability—as well as the journal organizations themselves—will be surprised to learn that the PTO does not consider them to be credible.

Assuming such recognized standards are in place—though highly doubtful—the PTO also should be required to show that these standards have been applied consistently to all patent applicants and not applied just arbitrarily to this one Applicant. Applicant further requests that the PTO provide a list of those scientific journals it now considers to be sufficiently credible under these standards. This way, Applicant will at least have the option of submitting his technical papers to only those so-called “credible” journals that the PTO is willing to take seriously.<sup>6</sup>

Applicant suspects that these standards do not exist and that, consistent with past practices in other BlackLight cases, the PTO has once again erected arbitrary barriers against this one particular Applicant to ensure that allowance is not an option in this case. Applicant again directs the PTO's attention to the attached May 1, 2003 “Supplemental Response” filed in App'n Ser. No. 09/110,678 (Tab D) and restates the demands therein (p. 8), including in particular: (3) the issuance of this and other allowable BlackLight applications in accordance with the representations and agreements made at the February 11, 2003 Interview.

The similarities between the events that took place during and following that Interview to those events occurring in this case can not be easily overlooked. Like Quality Assurance Specialist Douglas McGinty, who gave specific direction at the February 11 Interview what evidence Applicant needed to present to get claims allowed, Examiner Wells also gave Applicant direction what evidence he wanted to see presented. And just as Applicant provided the evidence Specialist McGinty requested to demonstrate the existence of novel hydrogen species having lower energy states, so too did Applicant present the evidence Examiner Wells requested showing “a shift in the Lyman series lines towards the far ultra-violet . . . [as] compared to the regular hydrogen series.” [See Final Office Action at p. 2 and Rule 116 Amendment at pp. 15-17] The final similarity, of course, was the PTO's complete renunciation of the representations that led Applicant to believe that allowance was a realistic option in all of these cases.

Despite these impediments, Applicant remains undeterred. Thus, even under the PTO's newly minted standards for evaluating his published technical papers, Applicant

---

<sup>6</sup> It would have been extremely helpful if, back in February 2001, when Examiner Jagannathan required the publication of scientific data, he had informed Applicant that the Secret Committee had a narrow list of scientific



is prepared to show that those standards have been clearly met. Indeed, Applicant has first-hand knowledge of, and can attest to, the rigorous peer review process that preceded publication of many of his papers. In most cases, Applicant was required to conduct additional experimentation and to rewrite portions of his papers to satisfy the numerous PhD scientists conducting the review.

If the PTO is aware of facts—as opposed to mere speculation—contradicting Applicant's personal experience with that review process, it is incumbent upon the PTO to come forward with that information. The PTO's failure to do so merely undercuts its already baseless argument that most of Applicant's technical papers "have not yet been published in scientifically qualified journals with appropriate review process so that they are not yet credible."

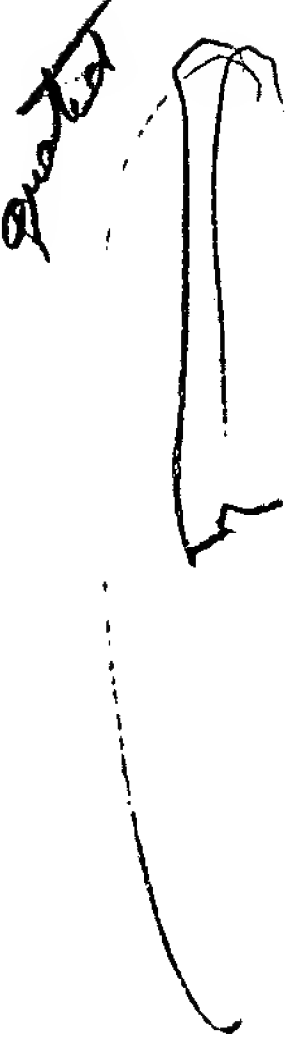
Regardless of the actual number of Applicant's technical papers that meet the PTO's new arbitrary standards, for those papers that do meet them by having been published in "scientifically qualified journals" after undergoing the "appropriate review process," those papers must now be deemed credible under those standards. Applicant, therefore, requests that the PTO give those papers the proper weight they are due and issue Applicant his patent based on the published scientific data showing the existence of lower energy states of hydrogen.

Applicant cites for further consideration additional scientific data in support of his claimed invention that has been published in peer-reviewed technical papers appearing in the following new journals:


- Applied Physics Letters;
- Chemistry of Materials;
- Europhysics Letters;
- European Journal of Physics;
- European Physics Journal B;
- Fuels and Energy;
- Journal of Hydrogen Energy;
- Journal of New Materials for Electrochemical Systems;
- Journal of Physics D, Applied Physics;

journals it would consider credible. This could have saved Applicant considerable time and expense.

Journal of Physical Chemistry A;  
Journal of Plasma Physics;  
Journal of Quantitative Spectroscopy and Radiative Transfer;  
Journal Vacuum Science and Technology;  
Materials Characterization;  
Optical Materials;  
Physics Essays;  
Physica B;  
Plasma Sources Science and Technology;  
Solar Energy Materials & Solar Cells;  
Thermochimica Acta;  
Thin Solid Films;  
Vacuum; and  
Vibrational Spectroscopy.

*Quoted*  In view of the new standards being imposed on evaluating the credibility of Applicant's technical papers, it is only fair that the reference materials cited by Examiner Souw in the Appendix attached to the May 7 Advisory Action be subjected to the same standards. Even upon cursory inspection, it is evident that many of these materials have not been published in accredited journals and most certainly have not been subjected to any peer review, as compared to Applicant's technical papers that have been peer-reviewed in the above-listed Journals. Those materials, therefore, should not be afforded any credibility whatsoever in accordance with the PTO's own analysis.

One paper relied on by the PTO is particularly troubling, *i.e.*, Peter D. Zimmerman's non-peer-reviewed, unsubstantiated comments appearing in a paper entitled, "An Analysis of Theoretical Flaws in So-Called Classical Quantum Mechanics and of Experimental Evidence against CQM." The PTO needs no reminding that Dr. Zimmerman is the former Chief Scientist for the U.S. State Department who published an Abstract of a proposed APS speech boasting how his Department and the Patent Office "have fought back with success" against BlackLight. It was Dr. Zimmerman, of course, who informed Applicant that his colleague, Dr. Robert Park—spokesman for BlackLight's competitor the American Physical Society (APS)—has communicated with



a PTO contact he refers to as "Deep Throat" with access to confidential patent information. [See March 6, 2003 "Response" filed in App'n Ser. No. 09/110,678, pp. 4-5]<sup>7</sup>

Even more disturbing is that the PTO is obviously continuing to cooperate with Dr. Zimmerman in thwarting Applicant's patent rights, as his copyright notice makes clear:

This entire article is copyright 2001 by Peter D. Zimmerman. No forwarding, reposting, copying, excerpting or direct quotation **whatsoever**, even for the purpose of reviews, or storage in any data base or storage system other than the HSG files on Yahoo.com or on the author's personal computer is permitted without the express written permission of the author.

© Peter D. Zimmerman, 2001. All rights reserved.

[Emphasis in original.] Applicant must assume that the PTO, an agency obviously well versed in intellectual property rights, would not have willfully violated the terms of Dr. Zimmerman's copyright notice prominently displayed on the front of the paper in question.

Thus, it must be presumed that the agency has been in contact with Dr. Zimmerman, at the very least to secure his permission to reproduce this paper, if not to secure his cooperation in others ways that undermine Applicant's patent rights. Applicant is entitled to know the extent of those contacts and the nature of any communications between the PTO and either Dr. Zimmerman or his colleague Dr. Park.

Applicant further points out that the PTO has simply ignored Dr. Mills' extensive rebuttal comments to Dr. Zimmerman's paper on the same internet chat room that Dr. Zimmerman posted his paper. Applicant provides a copy of those rebuttal comments and requests that the PTO fully consider Dr. Mills' comments with the same level of reliability accorded Dr. Zimmerman. [See Attachment B]

Applicant also notes with dismay the citation in the Appendix to Examiner Souw's own technical papers published in the journal *Physica*. The citation of those papers is inherently unfair for several obvious reasons.

---

<sup>7</sup> Having injected Dr. Zimmerman into this case, the PTO is constrained to address the issues raised in this March 6, 2003 Response (Tab C) relating to the efforts of Dr. Zimmerman and his APS

First, the PTO has failed to show that the journals in which those technical papers appear are any more "scientifically qualified with appropriate review process" than the journals that published Applicant's papers. Unless and until the PTO does so, the credibility of Examiner Souw's papers will remain an issue and should not be cited against Applicant.

Second, for Examiner Souw to cite his own technical papers against Applicant makes it even more unfair, as it limits the Examiner's ability to remain impartial. How can an Examiner be expected to remain unbiased in the face of Applicant's critical arguments when it is his own technical paper that is the subject of those criticisms? The answer is obvious: he can't.

In any case, now that Examiner Souw has relied upon his own scientific research to support the PTO's final rejection, Applicant is entitled to know certain details of his background, including his technical education and past work experience.

Regarding the substance of the Appendix, it appears that Examiner Souw prefers engaging in a theoretical debate to the exclusion of Applicant's experimental evidence, putting his favored quantum theory, with all of its far-fetched and disproved predictions, against Applicant's theory of classical quantum mechanics that correctly predicts the formation of lower-energy hydrogen.

Applicant has willingly engaged the PTO in this debate in the past, and will continue to do so if necessary, even though the patent laws do not require that he understand the precise theoretical basis for why his invention works. All the law requires is that he disclose his invention in sufficient detail to enable one of ordinary skill in the art how to practice it. Applicant has done precisely that and the PTO has failed in its burden to show otherwise.

Of course, the debate over these competing theories can go on indefinitely without resolution, which may be the PTO's strategy. Engaging in that intellectual exercise, however, will not—indeed cannot—definitively settle the question of whether practicing Applicant's disclosed hydrogen chemistry results in the formation of lower-energy hydrogen. Like any good theoretical debate, this one can only be tested and ultimately settled by fairly analyzing the unprecedented amount of experimental

---

colleagues—Dr. Park in particular—to sabotage Applicant's patent rights.

evidence Applicant has submitted conclusively confirming the lower energy states of hydrogen.

Applicant has expended tens of millions of dollars amassing this experimental evidence. The least the PTO can do is properly consider it. The PTO's view, however, appears to be that, because the existence of lower-energy hydrogen is theoretically impossible—at least according to its misguided view of quantum mechanics—it need not analyze any contrary evidence. Applicant is hard pressed to imagine an approach to patent examination any more arbitrary and capricious than that.

Nevertheless, Applicant provides a complete and detailed response to each theoretical point raised by Examiner Souw and requests full consideration of that response. [See Attachment A].

In addition, Applicant submits with this RCE new scientific evidence demonstrating the existence of lower energy states of hydrogen in many different ways, including but not limited to, spectroscopic lines, energy output, compositions of matter, generated plasmas, and inverted hydrogen populations. This experimental evidence cannot be dismissed as being cumulative of earlier submitted experimental evidence.

Applicant respectfully demands that the PTO consider and evaluate in detail this and all other evidence of record so far ignored and, to the extent that it finds fault with any of the scientific data, that those findings be communicated to provide Applicant an opportunity to respond. Applicant also files herewith a Rule 132 Declaration certifying the newly submitted experimental evidence that has not yet completed the peer-reviewed process, which further rebuts the PTO's unjustified utility and enablement rejections of the claimed invention.

With this latest submission, Applicant now has over 90 articles and books of record in this case, as reflected in the "List of References" set forth below. The first 44 articles on this list, numbered 94-50, are the newly submitted articles to which Applicant just referred. Many articles in the list were submitted after the Final Office Action was mailed and have not yet been fully considered. Furthermore, many of the articles numbered 1-49 have now been fully peer-reviewed and published and, thus, should be fully considered and deemed credible by the Examiner under his newly imposed standards.



These articles detail studies that experimentally confirm a novel reaction of atomic hydrogen, which produces hydrogen in fractional quantum states that are at lower energies than the traditional "ground" ( $n = 1$ ) state, a chemically generated or assisted plasma (rt-plasma), and novel hydride compounds, including:

extreme ultraviolet (EUV) spectroscopy,<sup>8</sup>  
characteristic emission from catalysis and the hydride ion products,<sup>9</sup>  
lower-energy hydrogen emission,<sup>10</sup>  
plasma formation,<sup>11</sup>  
Balmer  $\alpha$  line broadening,<sup>12</sup>  
population inversion of hydrogen lines,<sup>13</sup>  
elevated electron temperature,<sup>14</sup>  
anomalous plasma afterglow duration,<sup>15</sup>  
power generation,<sup>16</sup>  
excessive light emission,<sup>17</sup> and  
analysis of chemical compounds.<sup>18</sup>

Direct plasma to electric power conversion is also possible.<sup>19</sup>

Exemplary studies include:

1.) the observation of intense extreme ultraviolet (EUV) emission at low temperatures (e.g.  $\approx 10^3 K$ ) from atomic hydrogen and only those atomized elements or gaseous ions which provide a net enthalpy of reaction of approximately  $m \cdot 27.2 eV$  via the ionization of  $t$  electrons to a continuum energy level where  $t$  and  $m$  are each an integer (e.g.  $K$ ,  $Cs$ , and  $Sr$  atoms and  $Rb^+$  ion ionize at integer multiples of the potential energy of atomic hydrogen

<sup>8</sup> Reference Nos. 11-16, 20, 24, 27-29, 31-36, 39, 42-43, 46-47, 50-52, 54-55, 57, 59, 63, 65-68, 70-76, 78-79, 81, 83, 85, 86, 89, 91-93

<sup>9</sup> Reference Nos. 24, 27, 32, 39, 42, 46, 51-52, 55, 57, 68, 72-73, 81, 89, 91

<sup>10</sup> Reference Nos. 14, 28-29, 33-36, 50, 63, 67, 70-71, 73, 75-76, 78-79, 86-87, 90, 92, 93

<sup>11</sup> Reference Nos. 11-13, 15-16, 20, 24, 27, 32, 39, 42, 46-47, 51-52, 54-55, 57, 72, 81, 89, 91-93

<sup>12</sup> Reference Nos. 16, 20, 30, 33-37, 39, 42-43, 49, 51-52, 54-55, 57, 63-65, 68-69, 71-74, 81-85, 88-89, 91, 92, 93

<sup>13</sup> Reference Nos. 39, 46, 51, 54, 55, 57, 59, 65-66, 68, 74, 83, 85, 89, 91

<sup>14</sup> Reference Nos. 34-37, 43, 49, 63, 67, 73

<sup>15</sup> Reference Nos. 12-13, 47, 81

<sup>16</sup> Reference Nos. 30-31, 33, 35-36, 39, 43, 50, 63, 71-73, 76-77, 81, 84, 89, 92, 93

<sup>17</sup> Reference Nos. 11, 16, 20, 23, 31, 37, 43, 52, 72

<sup>18</sup> Reference Nos. 6-10, 19, 25, 38, 41, 44-45, 60-62, 64, 69, 75, 81-82, 87-88, 90, 92, 93, 94

<sup>19</sup> Reference Nos. 18, 26, 40, 48, 56, 68

and caused emission; whereas, the chemically similar atoms, *Na*, *Mg*, and *Ba*, do not ionize at integer multiples of the potential energy of atomic hydrogen and caused no emission)<sup>20</sup>,

2.) the observation of novel EUV emission lines from microwave and glow discharges of helium with 2% hydrogen with energies of  $q \cdot 13.6 \text{ eV}$  where  $q = 1, 2, 3, 4, 6, 7, 8, 9, 11, 12$  or these lines inelastically scattered by helium atoms in the excitation of  $\text{He}(1s^2)$  to  $\text{He}(1s^1 2p^1)$  that were identified as hydrogen transitions to electronic energy levels below the "ground" state corresponding to fractional quantum numbers<sup>21</sup>,

3.) the observation of novel EUV emission lines from microwave and glow discharges of helium with 2% hydrogen at  $44.2 \text{ nm}$  and  $40.5 \text{ nm}$  with energies of  $q \cdot 13.6 + \left( \frac{1}{n_f^2} - \frac{1}{n_i^2} \right) \cdot 13.6 \text{ eV}$  where  $q = 2$  and  $n_f = 2, 4$   $n_i = \infty$  that corresponded to multipole coupling to give two-photon emission from a continuum excited state atom and an atom undergoing fractional Rydberg state transition<sup>22</sup>,

4.) the identification of transitions of atomic hydrogen to lower energy levels corresponding to lower-energy hydrogen atoms in the extreme ultraviolet emission spectrum from interstellar medium and the sun<sup>23</sup>,

5.) the observation that the novel EUV series of lines with energies of  $q \cdot 13.6 \text{ eV}$  was observed with an Evenson microwave cell, only a the peak corresponding to  $q = 2$  was observed with an RF cell, and none of the peaks were observed with a glow discharge cell<sup>24</sup>,

6.) the observation that in a comparison of Evenson, McCarroll, cylindrical, and Beenakker microwave cavity plasmas, the novel EUV series of lines with energies of  $q \cdot 13.6 \text{ eV}$  was only observed for Evenson-cavity helium-hydrogen plasmas<sup>25</sup>,

7.) the EUV spectroscopic observation of lines for a hydrogen-*K* catalyst plasma by the Institut für Niedertemperatur-Plasmaphysik e.V. that could be assigned to transitions of

<sup>20</sup> Reference Nos. 11-13, 15-16, 20, 24, 27, 32, 39, 42, 46-47, 51-52, 54-55, 57, 72, 81, 89, 91-93

<sup>21</sup> Reference Nos. 28, 33-36, 50, 63, 67, 71, 73, 75-76, 78, 86-87, 90, 92, 93

<sup>22</sup> Reference Nos. 36, 71, 73

<sup>23</sup> Reference Nos. 1, 5, 17, 28-29

<sup>24</sup> Reference Nos. 71, 73

<sup>25</sup> Reference No. 76

atomic hydrogen to lower energy levels corresponding to fractional principal quantum numbers and the emission from the excitation of the corresponding hydride ions<sup>26</sup>,

8.) the recent analysis of mobility and spectroscopy data of individual electrons in liquid helium which shows direct experimental confirmation that electrons may have fractional principal quantum energy levels<sup>27</sup>,

9.) the observation of novel EUV emission lines from microwave discharges of argon or helium with 10% hydrogen that matched those predicted for  $H(1/4) + H^+ \rightarrow H_2(1/4)^+$  with vibronic coupling at  $E_{D+vib} = 4^2 E_{D H_2^+} \pm \nu^* 2^2 E_{vib H_2^+ (\nu=0 \rightarrow \nu=1)}$ ,  $\nu^* = 0, 1, 2, 3, \dots$  at the longer wavelengths for  $\nu^* = 0$  to  $\nu^* = 20$  and at the shorter wavelengths for  $\nu^* = 0$  to  $\nu^* = 3$  where  $E_{D H_2^+}$  and  $E_{vib H_2^+ (\nu=0 \rightarrow \nu=1)}$  are the experimental bond and vibrational energies of  $H_2^+$ , respectively,<sup>28</sup>,

10.) the result that the novel vibrational series  $E_{D+vib} = 4^2 E_{D H_2^+} \pm \nu^* 2^2 E_{vib H_2^+ (\nu=0 \rightarrow \nu=1)}$  was only observed for catalyst plasmas of helium, neon, and argon mixed with hydrogen, but not with noncatalyst xenon or krypton mixed plasmas<sup>29</sup>,

11.) the observation that based on the intensities of the peaks, the catalyst and the plasma source dependence of the reaction rate to form  $H_2(1/4)^+$  is  $Ar^+ > He^+ > Ne^+$  and microwave > glow discharge >> RF, respectively<sup>30</sup>,

12.) the observation that the microwave plasma source dependence of the reaction rate to form  $H_2(1/4)^+$  is Evenson microwave > McCarroll, cylindrical, Beenakker<sup>31</sup>,

13.) the observation of EUV plasma emission spectra in the region 60 nm to 100 nm that matched the predicted emission lines  $E_{D H_2}$  due to the reaction  $2H(1/2) \rightarrow H_2(1/2)$  with vibronic coupling at energies of  $E_{D+vib} = 17.913 \pm \left(\frac{\nu^*}{3}\right) 0.515902 \text{ eV}$  to longer wavelengths for

<sup>26</sup> Reference No. 14

<sup>27</sup> Reference Nos. 17, 53

<sup>28</sup> Reference Nos. 29, 70, 73, 79, 92, 93

<sup>29</sup> Reference Nos. 29, 70, 73, 79, 92, 93

<sup>30</sup> Reference No. 70

<sup>31</sup> Reference No. 79

$\nu^* = 2$  to  $\nu^* = 32$  and to shorter wavelengths for  $\nu^* = 1$  to  $\nu^* = 16$  to within the spectrometer resolution of about  $\pm 0.05\%$ <sup>32</sup>,

14.) the observation that in addition to members of the series of novel emission lines with energies of  $q \cdot 13.6 \text{ eV}$  or  $E_{D+vib} = 17.913 \pm \left(\frac{\nu^*}{3}\right) 0.515902 \text{ eV}$  an additional intense peak was observed from a scaled-up Evenson cell at  $41.6 \text{ nm}$  with an energy of  $29.81 \text{ eV}$  that matched  $q \cdot 13.6 \text{ eV}$  with  $q = 4$  less  $24.58741 \text{ eV}$  corresponding to inelastic scattering of these photons by helium atoms due to ionization of  $\text{He}$  to  $\text{He}^+$ <sup>33</sup>,

15.) the observation that in a comparison of Evenson, McCarroll, cylindrical, and Beenakker microwave cavity plasmas, the novel series of spectral lines due to the reaction  $2\text{H}(1/2) \rightarrow \text{H}_2(1/2)$  with vibronic coupling at energies of  $E_{D+vib} = 17.913 \pm \left(\frac{\nu^*}{3}\right) 0.515902 \text{ eV}$  was only observed for Evenson-cavity helium-hydrogen and neon-hydrogen plasmas<sup>34</sup>,

16.) the observation by gas chromatography that hydrogen was consumed by the helium-hydrogen plasmas which showed the novel EUV series of lines with energies of  $q \cdot 13.6 \text{ eV}$ , the novel series of spectral lines due to the reaction  $2\text{H}(1/2) \rightarrow \text{H}_2(1/2)$  with vibronic coupling at energies of  $E_{D+vib} = 17.913 \pm \left(\frac{\nu^*}{3}\right) 0.515902 \text{ eV}$ , extraordinary H. Balmer line broadening corresponding to  $180\text{-}210 \text{ eV}$ , and excess power of  $21.9 \text{ W}$  in  $3 \text{ cm}$ <sup>35</sup>,

17.) the observation of the dominant  $\text{He}^+$  emission and an intensification of the plasma emission observed when  $\text{He}^+$  was present with atomic hydrogen demonstrated the role of  $\text{He}^+$  as a catalyst<sup>36</sup>,

18.) the observation of continuum state emission of  $\text{Cs}^{2+}$  and  $\text{Ar}^{2+}$  at  $53.3 \text{ nm}$  and  $45.6 \text{ nm}$ , respectively, with the absence of the other corresponding Rydberg series of lines from these species which confirmed the resonant nonradiative energy transfer of  $27.2 \text{ eV}$  from atomic hydrogen to the either  $\text{Cs}$  or  $\text{Ar}^+$  catalyst<sup>37</sup>,

<sup>32</sup> Reference Nos. 50, 75-76, 78, 86-87, 90, 92, 93

<sup>33</sup> Reference No. 86

<sup>34</sup> Reference No. 76

<sup>35</sup> Reference No. 76

<sup>36</sup> Reference Nos. 36, 73

<sup>37</sup> Reference Nos. 24, 39, 51, 54-55, 57, 91

19.) the spectroscopic observation of the predicted hydride ion  $H^-(1/2)$  of hydrogen catalysis by either  $Cs$  or  $Ar^+$  catalyst at  $407\text{ nm}$  corresponding to its predicted binding energy of  $3.05\text{ eV}$ <sup>38</sup>,

20.) the observation of characteristic emission from  $K^{3+}$  which confirmed the resonant nonradiative energy transfer of  $3 \cdot 27.2\text{ eV}$  from atomic hydrogen to atomic  $K$ <sup>39</sup>,

21.) the spectroscopic observation of the predicted  $H^-(1/4)$  ion of hydrogen catalysis by  $K$  catalyst at  $110\text{ nm}$  corresponding to its predicted binding energy of  $11.2\text{ eV}$ <sup>40</sup>,

22.) the observation of characteristic emission from  $Rb^{2+}$  which confirmed the resonant nonradiative energy transfer of  $27.2\text{ eV}$  from atomic hydrogen to  $Rb^+$ <sup>41</sup>,

23.) the spectroscopic observation of the predicted  $H^-(1/2)$  ion of hydrogen catalysis by  $Rb^+$  catalyst at  $407\text{ nm}$  corresponding to its predicted binding energy of  $3.05\text{ eV}$ <sup>42</sup>,

24.) the observation of  $H^-(1/2)$ , the hydride ion catalyst product of  $K^+/K^+$  or  $Rb^+$ , at its predicted binding energy of  $3.0468\text{ eV}$  by high resolution visible spectroscopy as a continuum threshold at  $4068.2\text{ Å}$  and a series of structures peaks separated from the binding energy by an integer multiple of the fine structure of  $H(1/2)$  starting at  $4071\text{ Å}$ <sup>43</sup>,

25.) the observation that the high resolution visible  $K^+/K^+$  or  $Rb^+-H_2$  plasma emission spectra in the region of  $4995$  to  $4060\text{ Å}$  matched the predicted bound-free hyperfine structure lines  $E_{HF}$  of  $H^-(1/2)$  calculated from the electron  $g$  factor as  $E_{HF} = j^2 3.00213 \times 10^{-5} + 3.0563\text{ eV}$  ( $j$  is an integer) for  $j=1$  to  $j=39$  ( $3.0563\text{ eV}$  to  $3.1012\text{ eV}$ —the hydride binding energy peak plus one and five times the spin-pairing energy, respectively) to within a 1 part per  $10^4$ <sup>44</sup>,

26.)  $Rb^+$  or  $2K^+$  catalysts formed a plasma having strong VUV emission with a stationary inverted Lyman population with an overpopulation sufficient for lasing, and

<sup>38</sup> Reference No. 24

<sup>39</sup> Reference Nos. 27, 39, 42, 46, 51, 54-55, 57, 81, 89, 91

<sup>40</sup> Reference Nos. 81, 42, 27

<sup>41</sup> Reference Nos. 32, 39, 42, 46, 51, 54-55, 57, 81, 89, 91

<sup>42</sup> Reference No. 32

<sup>43</sup> Reference Nos. 39, 42, 46, 57, 81, 89, 91

<sup>44</sup> Reference Nos. 39, 42, 46, 57, 81, 89, 91



emission from  $H^-(1/2)$  was observed at 4071 Å corresponding to its predicted binding energy of 3.0468 eV with the fine structure and its predicted bound-free hyperfine structure lines  $E_{HF} = j^2 3.00213 \times 10^{-5} + 3.0563 \text{ eV}$  ( $j$  is an integer) that matched for  $j=1$  to  $j=37$  to within a 1 part per  $10^{445}$ ,

27.) the observation of stationary inverted H Balmer and Lyman populations from a low pressure water-vapor microwave discharge plasma with an overpopulation sufficient for lasing at wavelengths over a wide range from micron to blue wherein molecular oxygen served as the catalyst as supported by  $O^{2+}$  emission and H Balmer line broadening of 55 eV compared to 1 eV for hydrogen alone<sup>46</sup>,

28.) the observation of H Balmer line broadening of 55 eV compared to 1 eV for hydrogen alone at distances up to 5 cm from the coupler<sup>47</sup>,

29.) the observation that with a microwave input power of  $9 \text{ W} \cdot \text{cm}^{-3}$ , a collisional radiative model showed that the hydrogen excited state population distribution was consistent with an  $n=1 \rightarrow 5,6$  pumping power of an unprecedented  $200 \text{ W} \cdot \text{cm}^{-3}$  permissive of gas laser efficiencies orders of magnitude those of conventional visible gas lasers and direct generation of electrical power using photovoltaic conversion of the spontaneous or stimulated water vapor plasma emission<sup>48</sup>;

30.) the observation of stimulation of the stationary inverted H Balmer population from a low pressure water-vapor microwave discharge plasma by back illumination with an infrared source that showed depopulation of the  $n=5$  state<sup>49</sup>,

31.) the observation of stationary inverted H Balmer and Lyman populations from a low pressure water-vapor microwave discharge plasma with an overpopulation sufficient for lasing was observed for Evenson microwave plasmas, but not for RF or discharge plasmas<sup>50</sup>,

32.) the observation of stationary inverted H Balmer and Lyman populations from a low pressure water-vapor microwave discharge plasma with an overpopulation sufficient for

<sup>45</sup> Reference Nos. 39, 42, 46, 51, 54, 55, 57, 81, 89, 91

<sup>46</sup> Reference Nos. 59, 65-66, 68, 74, 83, 85

<sup>47</sup> Reference No. 74

<sup>48</sup> Reference Nos. 68, 83, 85

<sup>49</sup> Reference Nos. 59, 65, 68, 85

<sup>50</sup> Reference Nos. 59, 65-66, 68, 73, 83, 85

lasing that was dependent on the microwave plasma source with the highest inversion from Evenson microwave plasmas<sup>51</sup>,

33.) the observation of stationary inverted H Balmer and Lyman populations from a low pressure water-vapor microwave discharge plasma with an overpopulation sufficient for lasing that was dependent on the pressure of the Evenson microwave plasma<sup>52</sup>,

34.) the observation of stationary inverted H Balmer populations from a low pressure water-vapor microwave discharge plasma with an overpopulation sufficient for lasing at distances up to 5 cm from the coupler<sup>53</sup>,

35.) the observation that the requirement for the natural hydrogen-oxygen stoichiometry of the Evenson water plasma was stringent in that a deviation by over 2% excess of either gas caused a reversal of the H inversion in water vapor plasmas<sup>54</sup>,

36.) the observation by the Institut für Niedertemperatur-Plasmaphysik e.V. of an anomalous plasma and plasma afterglow duration formed with hydrogen-potassium mixtures<sup>55</sup>,

37.) the observation of anomalous afterglow durations of plasmas formed by catalysts providing a net enthalpy of reaction within thermal energies of  $m \cdot 27.28 \text{ eV}$ <sup>56</sup>,

38.) the formation of a chemically generated hydrogen plasma with the observation of Lyman series in the EUV that represents an energy release about 10 times that of hydrogen combustion which is greater than that of any possible known chemical reaction<sup>57</sup>,

39.) the observation of line emission by the Institut für Niedertemperatur-Plasmaphysik e.V. with a 4° grazing incidence EUV spectrometer that was 100 times more energetic than the combustion of hydrogen<sup>58</sup>,

---

<sup>51</sup> Reference No. 83

<sup>52</sup> Reference Nos. 59, 68, 73, 83, 85

<sup>53</sup> Reference No. 74

<sup>54</sup> Reference Nos. 59, 68, 83, 85

<sup>55</sup> Reference Nos. 13, 47, 81

<sup>56</sup> Reference Nos. 12, 13, 47, 81

<sup>57</sup> Reference Nos. 11-13, 15-16, 20, 24, 27, 32, 39, 42, 46-47, 51-52, 54-55, 57, 72, 81, 89, 91

<sup>58</sup> Reference No. 14

40.) the excessive increase in the Lyman emission upon the addition of helium or argon catalyst to a hydrogen plasma<sup>59</sup>,

41.) the observation of the characteristic emission from  $Sr^+$  and  $Sr^{3+}$  that confirmed the resonant nonradiative energy transfer of  $2 \cdot 27.2 \text{ eV}$  from atomic hydrogen to  $Sr^+$ <sup>60</sup>,

42.) the observation of anomalous plasmas formed with  $Sr$  and  $Ar^+$  catalysts at 1% of the theoretical or prior known voltage requirement with a light output per-unit-power input up to 8600 times that of the control standard light source<sup>61</sup>,

43.) the observation that the optically measured output power of gas cells for power supplied to the glow discharge increased by over two orders of magnitude depending on the presence of less than 1% partial pressure of certain catalysts in hydrogen gas or argon-hydrogen gas mixtures, and an excess thermal balance of 42 W was measured for the 97% argon and 3% hydrogen mixture versus argon plasma alone<sup>62</sup>,

44.) the observation that glow discharge plasmas of the catalyst-hydrogen mixtures of strontium-hydrogen, helium-hydrogen, argon-hydrogen, strontium-helium-hydrogen, and strontium-argon-hydrogen showed significant Balmer  $\alpha$  line broadening corresponding to an average hydrogen atom temperature of  $25 - 45 \text{ eV}$ ; whereas, plasmas of the noncatalyst-hydrogen mixtures of pure hydrogen, krypton-hydrogen, xenon-hydrogen, and magnesium-hydrogen showed no excessive broadening corresponding to an average hydrogen atom temperature of  $\approx 3 \text{ eV}$ <sup>63</sup>,

45.) the observation that microwave helium-hydrogen and argon-hydrogen plasmas having catalyst  $Ar^+$  or  $He^+$  showed extraordinary Balmer  $\alpha$  line broadening due to hydrogen catalysis corresponding to an average hydrogen atom temperature of  $110 - 130 \text{ eV}$  and  $180 - 210 \text{ eV}$ , respectively; whereas, plasmas of pure hydrogen, neon-hydrogen, krypton-hydrogen, and xenon-hydrogen showed no excessive broadening corresponding to an average hydrogen atom temperature of  $\approx 3 \text{ eV}$ <sup>64</sup>,

<sup>59</sup> Reference Nos. 20, 31, 37, 43

<sup>60</sup> Reference Nos. 16, 52

<sup>61</sup> Reference Nos. 11, 16, 20, 23, 52, 72

<sup>62</sup> Reference No. 22

<sup>63</sup> Reference Nos. 16, 20, 30, 52, 72

<sup>64</sup> Reference Nos. 33-37, 43, 49, 60, 63-64, 69, 71, 73-74, 82, 84, 88, 92, 93

46.) the observation that microwave helium-hydrogen and argon-hydrogen plasmas showed average electron temperatures that were high,  $30,500 \pm 5\% K$  and  $13,700 \pm 5\% K$ , respectively; whereas, the corresponding temperatures of helium and argon alone were only  $7400 \pm 5\% K$  and  $5700 \pm 5\% K$ , respectively<sup>65</sup>,

47.) the observation of significant Balmer  $\alpha$  line broadening of 17, 9, 11, 14, and 24 eV from rt-plasmas of incandescently heated hydrogen with  $K^+ / K^+$ ,  $Rb^+$ , cesium, strontium, and strontium with  $Ar^+$  catalysts, respectively, wherein the results could not be explained by Stark or thermal broadening or electric field acceleration of charged species since the measured field of the incandescent heater was extremely weak, 1 V/cm, corresponding to a broadening of much less than 1 eV<sup>66</sup>,

48.) calorimetric measurement of excess power of 20 mW/cc on rt-plasmas formed by heating hydrogen with  $K^+ / K^+$  and  $Ar^+$  as catalysts<sup>67</sup>,

49.) the observation of rt-plasmas formed with strontium and argon at 1% of the theoretical or prior known voltage requirement with a light output per unit power input up to 8600 times that of the control standard light source as well as an excess power of 20 mW/cm from rt-plasmas formed by  $Ar^+$  as the catalyst in an incandescent-filament cell<sup>68</sup>,

50.) the Calvet calorimetry measurement of an energy balance of over  $-151,000 kJ/mole H_2$  with the addition of 3% hydrogen to a plasma of argon having the catalyst  $Ar^+$  compared to the enthalpy of combustion of hydrogen of  $-241.8 kJ/mole H_2$ ; whereas, under identical conditions no change in the Calvet voltage was observed when hydrogen was added to a plasma of noncatalyst xenon<sup>69</sup>,

51.) the observation that the power output exceeded the power supplied to hydrogen glow discharge plasmas by 35-184 W depending on the presence of catalysts from helium or argon and less than 1% partial pressure of strontium metal in noble gas-hydrogen mixtures; whereas, the chemically similar noncatalyst krypton had no effect on the power balance<sup>70</sup>,

<sup>65</sup> Reference Nos. 34-37, 43, 49, 63, 67, 73

<sup>66</sup> Reference Nos. 39, 42, 46, 51-52, 54-55, 57, 72, 81, 89, 91

<sup>67</sup> Reference Nos. 81, 39, 89

<sup>68</sup> Reference No. 72

<sup>69</sup> Reference No. 31

<sup>70</sup> Reference No. 30

52.) the observation that with the addition of 3% flowing hydrogen to an argon microwave plasma with a constant input power of 40 W, the gas temperature increased from 400°C to over 750°C; whereas, the 400°C temperature of a xenon plasma run under identical conditions was essentially unchanged with the addition of hydrogen<sup>71</sup>,

53.) observations of power such as that where the addition of 10% hydrogen to a helium microwave plasma maintained with a constant microwave input power of 40 W, the thermal output power was measured to be at least 280 W corresponding to a reactor temperature rise from room temperature to 1200°C within 150 seconds, a power density of 28 MW/m<sup>3</sup>, and an energy balance of at least  $-4 \times 10^5$  kJ/mole H<sub>2</sub> compared to the enthalpy of combustion of hydrogen of -241.8 kJ/mole H<sub>2</sub><sup>72</sup>,

54.) the observation of  $306 \pm 5$  W of excess power generated in 45 cm<sup>3</sup> by a compound-hollow-cathode-glow discharge of a neon-hydrogen (99.5/0.5%) mixture corresponding to a power density of 6.8 MW/m<sup>3</sup> and an energy balance of at least  $-1 \times 10^6$  kJ/mole H<sub>2</sub> compared to the enthalpy of combustion of hydrogen of -241.8 kJ/mole H<sub>2</sub><sup>73</sup>,

55.) the observation that for an input of 37.7 W, the total plasma power of the neon-hydrogen plasma measured by water bath calorimetry was 60.7 W corresponding to 23.0 W of excess power in 3 cm<sup>3</sup><sup>74</sup>,

56.) the observation of intense He<sup>+</sup> emission and a total plasma power of a helium-hydrogen plasma measured by water bath calorimetry of 30.0 W for an input of 8.1 W, corresponding to 21.9 W of excess power in 3 cm<sup>3</sup> wherein the excess power density and energy balance were high, 7.3 W/cm<sup>3</sup> and  $-2.9 \times 10^4$  kJ/mole H<sub>2</sub>, respectively<sup>75</sup>,

57.) in the comparison of helium-hydrogen plasmas sources, the observation that i.) with an input power of  $24.8 \pm 1$  W, the total plasma power of the Evenson microwave helium-hydrogen plasma measured by water bath calorimetry was  $49.1 \pm 1$  W corresponding to 24.3

---

<sup>71</sup> Reference No. 43

<sup>72</sup> Reference Nos. 34, 35

<sup>73</sup> Reference Nos. 50, 78

<sup>74</sup> Reference No. 76

<sup>75</sup> Reference Nos. 36, 63, 71, 73



$\pm 1$  W of excess power in  $3 \text{ cm}^3$  corresponding to a high excess power density and energy balance of  $8.1 \text{ W/cm}^3$  and over  $-3 \times 10^4 \text{ kJ/mole H}_2$ , respectively, ii.) with an input of 500 W, a total power of 623 W was generated in a  $45 \text{ cm}^3$  compound-hollow-cathode-glow discharge, iii.) less than 10% excess power was observed from inductively coupled-RF helium-hydrogen plasmas, and iv.) no measurable heat was observed from MKS/Astex microwave helium-hydrogen plasmas that corresponded to the absence of H Balmer line broadening<sup>76</sup>,

58.) the observation of energy balances of helium-hydrogen microwave plasmas of over 100 times the combustion of hydrogen and power densities greater than  $10 \text{ W/cm}^3$  measured by water bath calorimetry<sup>77</sup>,

59.) at the load matching condition of  $600 \Omega$ , the direct plasmadynamic conversion (PDC) of open circuit voltages of 11.5 V and ~200 mW of electrical power with a 0.125 in diameter by 3/4 in long plasmadynamic electrode and a 140 G applied field corresponding to an extracted power density of  $\sim 1.61 \text{ W/cm}^3$  and an efficiency of  $\sim 18.8\%$ <sup>78</sup>,

60.) at the load matching condition of  $250 \Omega$ , the direct plasmadynamic conversion (PDC) of open circuit voltages of 21.8 V and 1.87 W of electrical power with a 0.125 in diameter by 3/4 in long plasmadynamic electrode and a 140 G applied field corresponding to an extracted power density of  $3.6 \text{ W/cm}^3$  and an efficiency of  $42\%$ <sup>79</sup>,

61.) the projection that the generation of electricity using magnetohydrodynamic (MHD) conversion of the plasma particle energy of small to mid-size chemically assisted microwave or glow discharge plasma (ca-plasma) power sources in the range of a few hundred Watts to several 10's of kW for microdistributed commercial applications appears feasible at 50% efficiency or better with a simple compact design<sup>80</sup>,

62.) the differential scanning calorimetry (DSC) measurement of minimum heats of formation of *KHI* by the catalytic reaction of *K* with atomic hydrogen and *KI* that were over

<sup>76</sup> Reference No. 84

<sup>77</sup> Reference Nos. 34-36, 50, 63, 71, 73, 76-78, 84

<sup>78</sup> Reference No. 48

<sup>79</sup> Reference No. 56

<sup>80</sup> Reference No. 40

$-2000 \text{ kJ/mole } H_2$  compared to the enthalpy of combustion of hydrogen of  $-241.8 \text{ kJ/mole } H_2$ <sup>81</sup>,

63.) the isolation of novel hydrogen compounds as products of the reaction of atomic hydrogen with atoms and ions which formed an anomalous plasma as reported in the EUV studies<sup>82</sup>,

64.) the synthesis and identification of a novel diamond-like carbon film terminated with  $CH(1/p)$  ( $H^+ \text{ DLC}$ ) comprising high binding energy hydride ions was synthesized for the first time from solid carbon by a microwave plasma reaction of a mixture of 10-30% hydrogen and 90-70% helium wherein  $He^+$  served as a catalyst with atomic hydrogen to form the highly stable hydride ions and an energetic plasma<sup>83</sup>,

65.) the synthesis of polycrystalline diamond films on silicon substrates without diamond seeding by a very low power microwave plasma reaction of a mixture of helium-hydrogen-methane (48.2/48.2/3.6%) wherein  $He^+$  served as a catalyst with atomic hydrogen to form an energetic plasma with an average hydrogen atom temperature of 180-210 eV versus  $\approx 3 \text{ eV}$  for pure hydrogen and bombardment of the carbon surface by highly energetic hydrogen formed by the catalysis reaction may play a role in the formation of diamond<sup>84</sup>,

66.) the synthesis of polycrystalline diamond films on silicon substrates without diamond seeding by a very low power microwave plasma reaction of a mixture of argon-hydrogen-methane (17.5/80/2.5%) wherein  $Ar^+$  served as a catalyst with atomic hydrogen to form an energetic plasma with an average hydrogen atom temperature of 110-130 eV versus  $\approx 3 \text{ eV}$  for pure hydrogen and bombardment of the carbon surface by highly energetic hydrogen formed by the catalysis reaction may play a role in the formation of diamond<sup>85</sup>,

67.) the identification of a novel highly stable surface coating  $SiH(1/p)$  by time of flight secondary ion mass spectroscopy that showed  $SiH^+$  in the positive spectrum and  $H^-$  dominant in the negative spectrum and by X-ray photoelectron spectroscopy which showed that the  $H$  content of the  $SiH$  coatings was hydride ions,  $H^-(1/4)$ ,  $H^-(1/9)$ , and  $H^-(1/11)$

<sup>81</sup> Reference No. 25

<sup>82</sup> Reference Nos. 6-10, 19, 25, 38, 41, 44-45, 60-62, 75, 81, 87, 90, 92, 93

<sup>83</sup> Reference No. 60

<sup>84</sup> Reference Nos. 64, 69, 88

<sup>85</sup> Reference Nos. 82, 88

corresponding to peaks at 11, 43, and 55 eV, respectively, and showed that the surface was remarkably stable to air<sup>86</sup>,

68.) the isolation of novel inorganic hydride compounds such as  $KHKHCO_3$  and  $KH$  following each of the electrolysis and plasma electrolysis of a  $K_2CO_3$  electrolyte which comprised high binding energy hydride ions that were stable in water with their identification by methods such as (i) ToF-SIMS on  $KHKHCO_3$  which showed inorganic hydride clusters  $K[KHKHCO_3]^+$  and a negative ToF-SIMS dominated by hydride ion, (ii) X-ray photoelectron spectroscopy which showed novel peaks corresponding to high binding energy hydride ions, and (iii)  $^1H$  nuclear magnetic resonance spectroscopy which showed upfield shifted peaks corresponding to more diamagnetic, high-binding-energy hydride ions<sup>87</sup>,

69.) the identification of  $LiHCl$  comprising a high binding energy hydride ion by time of flight secondary ion mass spectroscopy which showed a dominant  $H^-$  in the negative ion spectrum, X-ray photoelectron spectroscopy which showed  $H^-(1/4)$  as a new peak at its predicted binding energy of 11 eV,  $^1H$  nuclear magnetic resonance spectroscopy which showed an extraordinary upfield shifted peak of -15.4 ppm corresponding to the novel hydride ion, and powder X-ray diffraction which showed novel peaks<sup>88</sup>,

70.) the identification of novel hydride compounds by a number of analytical methods such as (i) time of flight secondary ion mass spectroscopy which showed a dominant hydride ion in the negative ion spectrum, (ii) X-ray photoelectron spectroscopy which showed novel hydride peaks and significant shifts of the core levels of the primary elements bound to the novel hydride ions, (iii)  $^1H$  nuclear magnetic resonance spectroscopy (NMR) which showed extraordinary upfield chemical shifts compared to the NMR of the corresponding ordinary hydrides, and (iv) thermal decomposition with analysis by gas chromatography, and mass spectroscopy which identified the compounds as hydrides<sup>89</sup>,

71.) the NMR identification of novel hydride compounds  $MH^*X$  wherein  $M$  is the alkali or alkaline earth metal,  $X$ , is a halide, and  $H^*$  comprises a novel high binding energy hydride ion identified by a large distinct upfield resonance<sup>90</sup>,

---

<sup>86</sup> Reference Nos. 45, 61

<sup>87</sup> Reference Nos. 6-7, 9, 38, 41

<sup>88</sup> Reference Nos. 44, 62

<sup>89</sup> Reference Nos. 6-10, 19, 25, 38, 41, 44-45, 60-62, 75, 81, 87, 90, 92, 93

<sup>90</sup> Reference Nos. 10, 19, 41, 44, 62, 81

72.) the replication of the NMR results of the identification of novel hydride compounds by large distinct upfield resonances at Spectral Data Services, University of Massachusetts Amherst, University of Delaware, Grace Davison, and National Research Council of Canada<sup>91</sup>,

73.) the NMR identification of novel hydride compounds  $MH^*$  and  $MH_2^*$  wherein  $M$  is the alkali or alkaline earth metal and  $H^*$  comprises a novel high binding energy hydride ion identified by a large distinct upfield resonance that proves the hydride ion is different from the hydride ion of the corresponding known compound of the same composition<sup>92</sup>,

74.) the observation that the  $^1H$  MAS NMR spectrum of novel compound  $KH^*Cl$  relative to external tetramethylsilane (TMS) showed a large distinct upfield resonance at -4.4 corresponding to an absolute resonance shift of -35.9 ppm that matched the theoretical prediction of  $p = 4$ , and the novel peak of  $KH^*I$  at -1.5 ppm relative to TMS corresponding to an absolute resonance shift of -33.0 ppm matched the theoretical prediction of  $p = 2$ <sup>93</sup>,

75.) the observation that the predicted catalyst reactions, position of the upfield-shifted NMR peaks, and spectroscopic data for  $H^-(1/2)$  and  $H^-(1/4)$  were found to be in agreement<sup>94</sup>,

76.) the isolation of fraction-principal-quantum-level molecular hydrogen  $H_2(1/p)$  gas by liquefaction using an ultrahigh-vacuum, liquid nitrogen cryotrap, and the observations of novel peaks by cryogenic gas chromatography, a higher ionization energy than  $H_2$  by mass spectroscopy, a unique EUV emission spectrum by optical emission spectroscopy that shifted with deuterium substitution in a region where no hydrogen emission has ever been observed that unequivocally confirmed the existence of lower-energy molecular hydrogen, and upfield shifted NMR peaks at 2.18 and 3.47 ppm compared to that of  $H_2$  at 4.63 ppm<sup>95</sup>.

---

<sup>91</sup> Reference Nos. 19, 81

<sup>92</sup> Reference Nos. 19, 81

<sup>93</sup> Reference No. 81

<sup>94</sup> Reference No. 81

<sup>95</sup> Reference Nos. 75, 87, 90, 92, 93, 94

Applicant again respectfully demands that the PTO consider and evaluate in detail all of this record evidence, which, to date, it has largely ignored. The scientific data disclosed in this extensive body of evidence was collected and peer-reviewed with great care by a group of highly qualified scientists capable of understanding every detail of Applicant's technology. The very least the PTO can do is to also carefully evaluate that data in detail, article by article, keeping an open mind, so that Applicant is given a full and fair opportunity to present his case. If and when the PTO finally does so, Applicant believes it will find that the evidence overwhelmingly proves the existence of lower-energy hydrogen in accordance with his claimed invention.

If, on the other hand, the PTO should find true fault with any of that data on legitimate scientific grounds—not the kind of nitpicking Applicant has seen on theoretical grounds—it should communicate as much to afford Applicant the opportunity to respond. Such scientific give-and-take is the only way to advance the prosecution of this case.

Applicant also provides an alphabetical listing of independent third-party laboratories and universities that conducted the experiments and generated the scientific data relied upon and discussed in the 45 analytical studies that follow this list:

Advanced Research - Pirelli Labs, Milan, Italy

Aero Propulsion and Power Directorate, Wright Laboratory, Air Force Material Command (ASC), Wright-Patterson Air Force Base

Atomic Energy Canada Limited, Chalk River Laboratories

Brookhaven National Laboratory

Charles Evans & Associates, Sunnyvale, CA

Environmental Catalysis and Materials Laboratory of Virginia Polytechnic Institute

Franklin and Marshall College

Galbraith Laboratories, Inc., Knoxville, TN

Grace Davison, Columbia, MD



IC Laboratories, Amawalk, NY

Idaho National Engineering Laboratory

Institut für Niedertemperatur-Plasmaphysik e.V. (INP Greifswald, Germany)

Jobin Yvon Inc., Edison, NJ

Laboratory for Electrochemistry of Renewed Electrode-Solution Interface  
(LEPGER)

Liebert Corporation, Division of Emerson Corporation.

Los Alamos National Laboratory

Material Testing Laboratory, Pennington, NJ

MIT Lincoln Laboratories

Moscow Power Engineering Institute

NASA Lewis

National Research Council of Canada

PacifiCorp

Pennsylvania State University Chemical Engineering Department

Perkin-Elmer Biosystems, Framingham, MA

Ricerca, Inc., Painesville, Ohio

Rider University, Lawrenceville NJ

Rowan University Professors A. J. Marchese, P. M. Jansson, J. L. Schmalzel

Ruhr University, Bochum, Germany

Shrader Analytical & Consulting Laboratories

Spectral Data Services, Inc., Champaign, IL

S. S. W., University of Western Ontario, Canada

Surface Science Laboratories, Mountain View, CA

Thermacore, Inc., Lancaster, PA

University of Delaware, Wilmington, DE

University of Massachusetts Amherst, Amherst, MA

University of New Mexico

Westinghouse Electric Corporation

Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University,  
Bethlehem, PA

The following 45 abstracts briefly describe the analytical studies of the scientific data generated by these independent third parties (highlighted in underline).

47. R. L. Mills, P. Ray, M. Nansteel, J. He, X. Chen, A. Voigt, B. Dhandapani, Luca Gamberale, "Energetic Catalyst-Hydrogen Plasma Reaction as a Potential New Energy Source", European Physical Journal D, submitted.

Luca Gamberale of the Advanced Research - Pirelli Labs, Milan, Italy performed verification studies as a visiting researcher at BlackLight Power, Cranbury, NJ. The prior reported results of BlackLight Power, Inc. of a chemically generated hydrogen plasma, extraordinarily broadened atomic hydrogen lines, lower-energy atomic, molecular, and molecular-ion hydrogen lines, the isolation and characterization of lower-energy molecular hydrogen gas, and excess power measured by water bath calorimetry were replicated. Specifically, plasmas of certain catalysts such as  $Sr^+$ ,  $Ar^+$ ,  $Ne^+$ , and  $He^+$  mixed with hydrogen were studied for evidence of a novel energetic reaction. A hydrogen plasma was observed to form at low temperatures (e.g.  $\approx 10^3 K$ ) and an extraordinary low field strength of about 1-2 V/cm when argon and strontium were present with atomic hydrogen. RF and microwave plasmas were used to generate  $He^+$ ,  $Ne^+$ , and  $Ar^+$  catalysts. Extraordinarily fast H (40-50 eV) was observed by Balmer  $\alpha$  line broadening only, from plasmas having a catalyst with H. Novel extreme ultraviolet (EUV) emission lines were observed, that corresponded to a Rydberg series of H corresponding to fractional principal quantum numbers wherein  $n = \frac{1}{2}, \frac{1}{3}, \frac{1}{4}, \dots, \frac{1}{p}$ ; ( $p \leq 137$  is an integer) replaces the well known parameter  $n = \text{integer}$  in the Rydberg equation for hydrogen excited states. Corresponding emission

due to fraction-principal-quantum-level hydrogen molecular ion  $H_2^+(1/p)$  and molecular hydrogen  $H_2(1/p)$  were also observed.  $H_2(1/p)$  gas was isolated by liquefaction using an high-vacuum ( $10^{-6}$  Torr) capable, liquid nitrogen cryotrap and was characterized by gas chromatography (GC), mass spectroscopy (MS), visible and EUV optical emission spectroscopy (OES), and  $^1H$  NMR of the condensable gas dissolved in  $CDCl_3$  performed at Rider University, Lawrenceville NJ. Novel peaks were observed by cryogenic gas chromatography performed on the condensable gas which was highly pure hydrogen by MS and had a higher ionization energy than  $H_2$ . A unique EUV emission spectrum was observed by OES. The observation that the novel EUV emission spectrum shifted with deuterium substitution in a region where no hydrogen emission has ever been observed strongly supported the existence of lower-energy molecular hydrogen. Contaminants and exotic helium-hydrogen species were eliminated as the source of the reaction and condensed gas plasma emission spectra. Upfield shifted NMR peaks were observed at 3.22, 3.25, and 3.47 ppm compared to that of  $H_2$  at 4.63 ppm. Excess power was absolutely measured from the helium-hydrogen plasma. For an input of 44.3 W, the total plasma power of the helium-hydrogen plasma measured by water bath calorimetry was 62.9 W corresponding to 18.6 W of excess power in  $3\text{ cm}^3$ . The excess power density and energy balance were high,  $6.2\text{ W/cm}^3$  and  $-5 \times 10^4\text{ kJ/mole } H_2$  ( $240\text{ eV/H atom}$ ), respectively.

46. R. Mills, B. Dhandapani, M. Nansteel, J. He, P. Ray, "Liquid-Nitrogen-Condensable Molecular Hydrogen Gas Isolated from a Catalytic Plasma Reaction", J. Phys. Chem. B, submitted.

Extreme ultraviolet (EUV) spectroscopy was recorded on microwave discharges of helium with 2% hydrogen. Novel emission lines were observed with energies of  $q \cdot 13.6\text{ eV}$  where  $q = 1, 2, 3, 4, 6, 7, 8, 9, 11$  or these discrete energies less  $21.2\text{ eV}$  corresponding to inelastic scattering of these photons by helium atoms due to excitation of  $He(1s^2)$  to  $He(1s^1 2p^1)$ . These lines matched  $H(1/p)$ , fractional Rydberg states of atomic hydrogen, formed by a resonant nonradiative energy transfer to  $He^+$ . Corresponding emission due to the reaction  $2H(1/2) \rightarrow H_2(1/2)$  with vibronic coupling at  $E_{D+vib} = p^2 E_{D H_2} \pm \left(\frac{\nu^*}{3}\right) E_{vib H_2(\nu=0 \rightarrow \nu=1)}$ ,  $\nu^* = 1, 2, 3, \dots$  was observed at the longer wavelengths for  $\nu^* = 2$  to  $\nu^* = 32$  and at the shorter wavelengths for  $\nu^* = 1$  to  $\nu^* = 16$  where  $E_{D H_2}$  and  $E_{vib H_2(\nu=0 \rightarrow \nu=1)}$  are the experimental bond and vibrational energies of  $H_2$ , respectively. Fraction-principal-quantum-level molecular hydrogen  $H_2(1/p)$  gas was isolated by liquefaction using an high-vacuum ( $10^{-6}$  torr) capable, liquid nitrogen cryotrap and was characterized by gas chromatography (GC), mass spectroscopy (MS), visible and EUV optical emission spectroscopy (OES), and  $^1H$  NMR of

the condensable gas dissolved in  $CDCl_3$ , performed at Rider University, Lawrenceville NJ. Novel peaks were observed by cryogenic gas chromatography performed on the condensable gas which was highly pure hydrogen by MS and had a higher ionization energy than  $H_2$ . A unique EUV emission spectrum was observed by OES. The observation that the novel EUV emission spectrum shifted with deuterium substitution in a region where no hydrogen emission has ever been observed unequivocally confirmed the existence of lower-energy molecular hydrogen. Contaminants and exotic helium-hydrogen species were eliminated as the source of the reaction and condensed gas plasma emission spectra. Upfield shifted NMR peaks were observed at 3.22 and 3.47 ppm compared to that of  $H_2$  at 4.63 ppm. A theoretical rocketry propellant reaction is given that may be transformational.

**45. Dr. K.D. Keefer, Report on BlackLight Power Technology: Its Apparent Scientific Basis, State of Development and Stability for Commercialization by Liebert Corporation, (2001), and, Report on BlackLight Power Technology: Its Apparent Scientific Basis, State of Development and Stability for Commercialization, (2002).**

To separate reports disclosing the results of NMR, ToF-SIMS, XPS identification of novel hydrino hydride compounds and analysis of chemically-produced plasma by an expert hired by the Liebert Corporation, a division of the well-known and highly-respected Emerson Corporation. According to the expert's own words, he "observed demonstrations of the BlackLight Power (BLP) process and ...reached the inescapable conclusion that it is based on extraordinary chemical reactions that seem to release extraordinary amounts of energy.... It is [his] professional opinion that the BLP process represents a chemical conversion of atomic hydrogen unlike any previously reported [in] the archival scientific literature." Although the expert states that he was skeptical of Applicant's theory, he admitted that the chemical and plasma data did support Applicant's fractional quantum states and that he could offer no other explanation of the data using conventional quantum theory.

**44. A. J. Marchese, P. M. Jansson, J. L. Schmalzel, "The BlackLight Rocket Engine", Phase I Final Report, NASA Institute for Advanced Concepts Phase I, May 1-November 30, 2002, [http://www.niac.usra.edu/files/studies/final\\_report/pdf/752Marchese.pdf](http://www.niac.usra.edu/files/studies/final_report/pdf/752Marchese.pdf).**

Rowan University Professors A. J. Marchese, P. M. Jansson, J. L. Schmalzel performed verification studies as visiting researchers at BlackLight Power, Cranbury, NJ. The prior reported results of BlackLight Power, Inc. of extraordinarily broadened atomic hydrogen lines, population inversion, lower-energy hydrogen lines, and excess power

measured by water bath calorimetry were replicated. The application of the energetic hydrogen to propulsion was studied.

Specifically, the data supporting hydrinos was replicated. See

i.) BlackLight Process Theory (pp. 10-12) which gives the theoretical energy levels for hydrinos and the catalytic reaction to form hydrinos,

ii.) Unique Hydrogen Line Broadening in Low Pressure Microwave Water Plasmas (pp. 25-27, particularly Fig. 21) which shows that in the same microwave cavity driven at the same power, the temperature of the hydrogen atoms in the microwave plasma where the hydrino reaction was active was 50 times that of the control based on the spectroscopic line widths,

iii.) Inversion of the Line Intensities in Hydrogen Balmer Series (pp. 27-28, particularly Fig. 22) which shows for the first time in 40 years of intensive worldwide research that atomic hydrogen population inversion was achieved in a steady state plasma and supports the high power released from the reaction of hydrogen to form hydrinos,

iv.) Novel Vacuum Ultraviolet (VUV) Vibration Spectra of Hydrogen Mixture Plasmas (pp. 28-29, particularly Fig. 23) which shows a novel vibrational series of lines in a helium-hydrogen plasmas at energies higher than any known vibrational series and it identically matches the theoretical prediction of 2 squared times the corresponding vibration of the ordinary hydrogen species, and

v.) Water Bath Calorimetry Experiments Showing Increased Heat Generation (pp. 29-30, particularly Fig. 25) that shows that with exactly the same system and same input power, the heating of the water reservoir absolutely measured to 1% accuracy was equivalent to 55 to 62 W with the catalyst-hydrogen mixture compared to 40 W in the control without the possibility of the reaction to form hydrinos.

43. J. Phillips, R. L. Mills, X. Chen, "Water Bath Calorimetric Study of Excess Heat in 'Resonance Transfer' Plasmas", *Journal of Applied Physics*, submitted.

J. Phillips, Distinguished National Laboratory Professor at Los Alamos National Laboratory and University of New Mexico, performed verification studies as a visiting researcher at BlackLight Power, Cranbury, NJ. Water bath calorimetry was used to demonstrate one more peculiar phenomenon associated with a certain class of mixed gas plasmas termed resonant transfer, or rt-plasmas. Specifically,  $He/H_2(10\%)$  (500 mTorr),  $Ar/H_2(10\%)$  (500 mTorr), and  $H_2O(g)$  (200 mTorr) plasmas generated with an Evenson microwave cavity consistently yielded on the order of 50% more heat than non rt-plasma (controls) such as  $He$ ,  $Kr$ ,  $Kr/H_2(10\%)$ , under identical conditions of gas flow, pressure,



and microwave operating conditions. The excess power density of rt-plasmas was of the order  $10 \text{ W} \cdot \text{cm}^{-3}$ . In earlier studies with these same rt-plasmas it was demonstrated that other unusual features were present including dramatic broadening of the hydrogen Balmer series lines, unique vacuum ultraviolet (VUV) lines, and in the case of water plasmas, population inversion of the hydrogen excited states. Both the current results and the earlier results are completely consistent with the existence of a hitherto unknown exothermic chemical reaction, such as that predicted by Mills, occurring in rt-plasmas.

42. R. L. Mills, P. C. Ray, R. M. Mayo, M. Nansteel, B. Dhandapani, J. Phillips, "Spectroscopic Study of Unique Line Broadening and Inversion in Low Pressure Microwave Generated Water Plasmas", *Physics of Plasmas*, submitted.

J. Phillips, Distinguished National Laboratory Professor at Los Alamos National Laboratory and University of New Mexico, performed verification studies as a visiting researcher at BlackLight Power, Cranbury, NJ. It was demonstrated that low pressure ( $\sim 0.2$  Torr) water vapor plasmas generated in a 10 mm ID quartz tube with an Evenson microwave cavity show at least two features which are not explained by conventional plasma models. First, significant ( $> 2.5 \text{ \AA}$ ) hydrogen Balmer  $\alpha$  line broadening was recorded, of constant width, up to 5 cm from the microwave coupler. Only hydrogen, and not oxygen, showed significant line broadening. This feature, observed previously in hydrogen-containing mixed gas plasmas generated with high voltage DC and RF discharges was explained by some researchers to result from acceleration of hydrogen ions near the cathode. This explanation cannot apply to the line broadening observed in the (electrodeless) microwave plasmas generated in this work, particularly at distances as great as 5 cm from the microwave coupler. Second, dramatic inversion of the line intensities of both the Lyman and Balmer series, again, at distances up to 5 cm from the coupler were observed. The dramatic line inversion suggests the existence of a hitherto unknown source of pumping of the optical power in plasmas. Finally, it is notable that other aspects of the plasma including the  $OH^*$  rotational temperature and low electron concentrations are quite typical of plasmas of this type.

41. H. Conrads, R. Mills, Th. Wrubel, "Emission in the Deep Vacuum Ultraviolet from a Plasma Formed by Incandescently Heating Hydrogen Gas with Trace Amounts of Potassium Carbonate", *Plasma Sources Science and Technology*, Vol. 12, (2003), pp. 389-395.

The generation of a hydrogen plasma with intense extreme ultraviolet and visible emission was observed at Ruhr University, Bochum, Germany from low pressure hydrogen gas (0.1-1 mbar) in contact with a hot tungsten filament only when the filament heated a titanium dissociator coated with  $K_2CO_3$  above 750°C. The dissociator was electrically floated, and the electric field strength from the filament was about 1 V/cm, two orders of magnitude lower than the starting voltages measured for gas glow discharges. The emission of the  $H_\alpha$  and  $H_\beta$  transitions as well as the  $L_\alpha$  and  $L_\beta$  transitions were recorded and analyzed. The plasma seemed to be far from thermal equilibrium, and no conventional mechanism was found to explain the formation of a hydrogen plasma by incandescently heating hydrogen gas with the presence of trace amounts of  $K_2CO_3$ . The temporal behavior of the plasma was recorded via hydrogen Balmer alpha line emission when all power into the cell was terminated. A two second decay of the plasma was observed after a fast decay of the electric field to zero. The plasma was found to be dependent on the chemistry of atomic hydrogen with potassium since no plasma formed with  $Na_2CO_3$  replacing  $K_2CO_3$  and the time constant of the emission following the removal of all of the power to the cell matched that of the cooling of the filament and the resulting shift from atomic to molecular hydrogen. Our results indicate that a novel chemical power source is present that forms the energetic hydrogen plasma. The plasma is a potential new light source.

**40. R. Mills, "Observation of Extreme Ultraviolet Emission from Hydrogen-KI Plasmas Produced by a Hollow Cathode Discharge", Int. J. Hydrogen Energy, Vol. 26, No. 6, (2001), pp. 579-592.**

A high voltage discharge of hydrogen with and without the presence of a source of potassium, potassium iodide, in the discharge was performed at Institut für Niedertemperatur-Plasmaphysik e.V. (INP Greifswald, Germany) with a hollow cathode. It has been reported that intense extreme ultraviolet (EUV) emission was observed at low temperatures (e.g.  $< 10^3$  K) from atomic hydrogen and certain atomized elements or certain gaseous ions which ionize at integer multiples of the potential energy of atomic hydrogen, 27.2 eV [1, 3-5]. Two potassium ions or a potassium atom may each provide an electron ionization or transfer reaction that has a net enthalpy equal to an integer multiple of 27.2 eV. The spectral lines of atomic hydrogen were intense enough to be recorded on photographic films only when KI was present. EUV lines not assignable to potassium, iodine, or hydrogen were observed at 73.0, 132.6, 513.6, 677.8, 885.9, and 1032.9 Å. The lines are assigned to transitions of atomic hydrogen to lower energy levels corresponding to lower energy

hydrogen atoms called hydrino atoms and the emission from the excitation of the corresponding hydride ions formed from the hydrino atoms.

39. R. Mills, "Temporal Behavior of Light-Emission in the Visible Spectral Range from a Ti-K<sub>2</sub>CO<sub>3</sub>-H-Cell", *Int. J. Hydrogen Energy*, Vol. 26, No. 4, (2001), pp. 327-332.

Institut für Niedertemperatur-Plasmaphysik e.V. (INP Greifswald, Germany) reports the generation of a hydrogen plasma and extreme ultraviolet emission as recorded via the hydrogen Balmer emission in the visible range. Typically a hydrogen plasma is generated and the emission of extreme ultraviolet light from hydrogen gas is achieved via a discharge at high voltage, a high power inductively coupled plasma, or a plasma created and heated to extreme temperatures by RF coupling (e.g.  $> 10^6$  K) with confinement provided by a toroidal magnetic field. The observed plasma formed at low temperatures (e.g.  $\approx 10^3$  K) from atomic hydrogen generated at a tungsten filament that heated a titanium dissociator coated with potassium carbonate. The temporal behavior of the plasma was recorded via hydrogen Balmer alpha line emission when all power into the cell was terminated. A two second decay of the plasma was observed after a fast decay of the electric field to zero. The persistence of emission following the removal of all of the power to the cell indicates that a novel chemical power source is present that forms an energetic plasma in hydrogen. No unusual behavior was observed with the control sodium carbonate.

38. R. Mills, J. Sankar, P. Ray, J. He, A. Voigt, B. Dhandapani, "Synthesis and Characterization of Diamond Films from MPCVD of an Energetic Argon-Hydrogen Plasma and Methane ", *J. of Materials Research*, submitted.

Polycrystalline diamond films were synthesized on silicon substrates by a low power (~80 W) microwave plasma chemical vapor deposition (MPCVD) reaction of a mixture of argon-hydrogen-methane (17.5/80/2.5%). The films were characterized by time of flight secondary ion mass spectroscopy (ToF-SIMS), X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), Raman spectroscopy (Charles Evans & Associates, Sunnyvale, CA), scanning electron microscopy (SEM) (S. S. W., University of Western Ontario, Canada), and X-ray diffraction (XRD) (IC Laboratories, Amawalk, NY). It is proposed that  $Ar^+$  served as a catalyst with atomic hydrogen to form an energetic plasma.  $CH$ ,  $C_2$ , and  $C_3$  emissions were observed with significantly broadened H  $\alpha$  line. The average hydrogen atom temperature of a argon-hydrogen plasma was measured to be 110–130 eV versus  $\approx 3$  eV for pure hydrogen. Bombardment of the carbon surface by highly energetic hydrogen formed by the catalysis

reaction may play a role in the formation of diamond. Then, by this novel pathway, the relevance of the *CO* tie line is eliminated along with other stringent conditions and complicated and inefficient techniques which limit broad application of the versatility and superiority of diamond thin film technology.

37. R. Mills, P. Ray, B. Dhandapani, W. Good, P. Jansson, M. Nansteel, J. He, A. Voigt, "Spectroscopic and NMR Identification of Novel Hydride Ions in Fractional Quantum Energy States Formed by an Exothermic Reaction of Atomic Hydrogen with Certain Catalysts", J. Phys. Chem. A, submitted.

$2K^+$  to  $K + K^{2+}$  and  $K$  to  $K^{3+}$  provide a reaction with a net enthalpy equal to the one and three times the potential energy of atomic hydrogen, respectively. The presence of these gaseous ions or atoms with thermally dissociated hydrogen formed a so-called resonance transfer (rt) plasma having strong VUV emission with a stationary inverted Lyman population. Significant line broadening of the Balmer  $\alpha$ ,  $\beta$ , and  $\gamma$  lines of 18 eV was observed, compared to 3 eV from a hydrogen microwave plasma. Emission from rt-plasmas occurred even when the electric field applied to the plasma was zero as recorded at Institut für Niedertemperatur-Plasmaphysik e.V. (INP Greifswald, Germany). The reaction was exothermic since excess power of  $20 \text{ mW} \cdot \text{cm}^{-3}$  was measured by Calvet calorimetry. An energetic catalytic reaction was proposed involving a resonant energy transfer between hydrogen atoms and  $2K^+$  or  $K$  to form very stable novel hydride ions  $H^-(1/p)$  called hydrino hydrides having a fractional principal quantum numbers  $p=2$  and  $p=4$ , respectively. Characteristic emission was observed from  $K^{2+}$  and  $K^{3+}$  that confirmed the resonant nonradiative energy transfer of  $27.2 \text{ eV}$  and  $3 \cdot 27.2 \text{ eV}$  from atomic hydrogen to  $2K^+$  and  $K$ , respectively.

The predicted binding energy of  $H^-(1/2)$  of  $3.0471 \text{ eV}$  with the fine structure was observed at  $4071 \text{ \AA}$ , and its predicted bound-free hyperfine structure lines  $E_{HF} = j^2 3.00213 \times 10^{-5} + 3.0563 \text{ eV}$  ( $j$  is an integer) matched those observed for  $j=1$  to  $j=37$  to within a 1 part per  $10^4$ .  $H^-(1/4)$  was observed spectroscopically at  $110 \text{ nm}$  corresponding to its predicted binding energy of  $11.2 \text{ eV}$ . The  $^1\text{H}$  MAS NMR spectrum (Spectral Data Services, Inc., Champaign, IL) of novel compound  $KH^*Cl$  relative to external tetramethylsilane (TMS) showed a large distinct upfield resonance at  $-4.4$  corresponding to an absolute resonance shift of  $-35.9 \text{ ppm}$  that matched the theoretical prediction of  $p=4$ . A novel NMR (Grace Davison, Columbia, MD and Spectral Data Services, Inc., Champaign, IL) peak of  $KH^*I$  at  $-1.5 \text{ ppm}$  relative to TMS corresponding to an absolute resonance shift of  $-33.0 \text{ ppm}$  matched the theoretical prediction of  $p=2$ . The predicted catalyst reactions,



position of the upfield-shifted NMR peaks, and spectroscopic data for  $H(1/2)$  and  $H(1/4)$  were found to be in agreement.

**36. R. L. Mills, P. Ray, B. Dhandapani, J. He, "Novel Liquid-Nitrogen-Condensable Molecular Hydrogen Gas", Polish Journal of Chemistry, submitted.**

Extreme ultraviolet (EUV) spectroscopy was recorded on microwave discharges of helium with 2% hydrogen. Novel emission lines were observed with energies of  $q \cdot 13.6 \text{ eV}$  where  $q = 1, 2, 3, 4, 6, 7, 8, 9, 11$  or these discrete energies less  $21.2 \text{ eV}$  corresponding to inelastic scattering of these photons by helium atoms due to excitation of  $He(1s^2)$  to  $He(1s^1 2p^1)$ . These lines matched  $H(1/p)$ , fractional Rydberg states of atomic hydrogen, formed by a resonant nonradiative energy transfer to  $He^+$ . Corresponding emission due to the reaction  $2H(1/2) \rightarrow H_2(1/2)$  with vibronic coupling at  $E_{D+vib} = p^2 E_{D H_2} \pm \left(\frac{\nu^*}{3}\right) E_{vib H_2(\nu=0 \rightarrow \nu=1)}$ ,  $\nu^* = 1, 2, 3, \dots$  was observed at the longer wavelengths for  $\nu^* = 2$  to  $\nu^* = 32$  and at the shorter wavelengths for  $\nu^* = 1$  to  $\nu^* = 16$  where  $E_{D H_2}$  and  $E_{vib H_2(\nu=0 \rightarrow \nu=1)}$  are the experimental bond and vibrational energies of  $H_2$ , respectively. Fractional-principal-quantum-level molecular hydrogen  $H_2(1/p)$  gas was isolated by liquefaction using an ultrahigh-vacuum, liquid nitrogen cryotrap and was characterized by gas chromatography (GC), mass spectroscopy (MS), optical emission spectroscopy (OES), and  $^1H$  NMR (Rider University, Lawrenceville NJ) of the condensable gas dissolved in  $CDCl_3$ . The condensable gas was highly pure hydrogen by GC and MS and had a higher ionization energy than  $H_2$ . An upfield shifted NMR peak was observed at 3.25 ppm compared to that of  $H_2$  at 4.63 ppm. A theoretical rocketry propellant reaction is given that may be transformational.

**35. R. L. Mills, J. Sankar, A. Voigt, J. He, B. Dhandapani, "Spectroscopic Characterization of the Atomic Hydrogen Energies and Densities and Carbon Species During Helium-Hydrogen-Methane Plasma CVD Synthesis of Single Crystal Diamond Films", Chemistry of Materials, Vol. 15, (2003), pp. 1313-1321.**

Polycrystalline diamond films were synthesized on silicon substrates for the first time without diamond seeding by a very low power (38 W) microwave plasma continuous vapor deposition (MPCVD) reaction of a mixture of helium-hydrogen-methane (48.2/48.2/3.6%). The films were characterized by time of flight secondary ion mass spectroscopy (ToF-SIMS), X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), Raman spectroscopy (Charles Evans & Associates, Sunnyvale, CA and Jobin Yvon Inc., Edison, NJ), scanning electron microscopy (SEM) (S. S. W., University of Western Ontario, Canada and Material Testing Laboratory,



Pennington, NJ), and X-ray diffraction (XRD) (IC Laboratories, Amawalk, NY). It is proposed that  $He^+$  served as a catalyst with atomic hydrogen to form an energetic plasma.  $CH$ ,  $C_2$ , and  $C_3$  emissions were observed with significantly broadened H  $\alpha$ ,  $\beta$ ,  $\gamma$ , and  $\delta$  lines. The average hydrogen atom temperature of a helium-hydrogen-methane plasma was measured to be 120-140 eV versus  $\approx 3$  eV for pure hydrogen. Bombardment of the carbon surface by highly energetic hydrogen formed by the catalysis reaction may play a role in the formation of diamond. Then, by this novel pathway, the relevance of the CO tie line is eliminated along with other stringent conditions and complicated and inefficient techniques which limit broad application of the versatility and superiority of diamond thin film technology.

34. R. L. Mills, J. Sankar, A. Voigt, J. He, B. Dhandapani, "Low Power MPCVD of Diamond Films on Silicon Substrates", *Journal of Vacuum Science & Technology A*, submitted.

Polycrystalline diamond films were synthesized on silicon substrates for the first time without diamond seeding by a very low power (38 W) microwave plasma continuous vapor deposition (MPCVD) reaction of a mixture of 10-30% hydrogen, 90-70% helium, and 1-10%  $CH_4$ . The films were characterized by time of flight secondary ion mass spectroscopy (ToF-SIMS), X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), Raman spectroscopy (Charles Evans & Associates, Sunnyvale, CA), scanning electron microscopy (SEM) (S. S. W., University of Western Ontario, Canada and Material Testing Laboratory, Pennington, NJ), and X-ray diffraction (XRD) (IC Laboratories, Amawalk, NY). It is proposed that  $He^+$  served as a catalyst with atomic hydrogen to form an energetic plasma. The average hydrogen atom temperature was measured to be 180-210 eV versus  $\approx 3$  eV for pure hydrogen. The electron temperature  $T_e$  for helium-hydrogen was 28,000 K compared to 6800 K for pure helium. Bombardment of the carbon surface by highly energetic hydrogen formed by the catalysis reaction may play a role in the formation of diamond. Then, by this novel pathway, the relevance of the CO tie line is eliminated along with other stringent conditions and complicated and inefficient techniques which limit broad application of the versatility and superiority of diamond thin film technology.

33. R. L. Mills, A. Voigt, B. Dhandapani, J. He, "Synthesis and Spectroscopic Identification of Lithium Chloro Hydride", *Materials Characterization*, submitted.

A novel inorganic hydride compound, lithium chloro hydride ( $LiHCl$ ), which comprises a high binding energy hydride ion was synthesized by reaction of atomic hydrogen with

potassium metal and lithium chloride. Lithium chloro hydride was identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA),  $^1\text{H}$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL), and powder X-ray diffraction (IC Laboratories, Amawalk, NY). Hydride ions with increased binding energies may form many novel compounds with broad applications such as the oxidant of a high voltage battery.

**32. R. L. Mills, B. Dhandapani, J. He, "Highly Stable Amorphous Silicon Hydride", Solar – Energy Materials & Solar Cells, in press.**

A novel highly stable hydrogen terminated silicon coating was synthesized by microwave plasma reaction of mixture of silane, hydrogen, and helium wherein it is proposed that  $\text{He}^+$  served as a catalyst with atomic hydrogen to form highly stable silicon hydrides. Novel silicon hydride was identified by time of flight secondary ion mass spectroscopy and X-ray photoelectron spectroscopy. The time of flight secondary ion mass spectroscopy (ToF-SIMS) identified the coatings as hydride by the large  $\text{SiH}^+$  peak in the positive spectrum and the dominant  $\text{H}^-$  in the negative spectrum. Since hydrogen is the only element with no primary element peaks, X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA) identified the  $\text{H}$  content of the  $\text{SiH}$  coatings as comprising novel silicon hydrides due to new peaks at 11, 43, and 55 eV in the absence of corresponding peaks of any candidate element at higher binding energies. The silicon hydride surface was remarkably stable to air as shown by XPS. The highly stable amorphous silicon hydride coating may advance the production of integrated circuits and microdevices by resisting the oxygen passivation of the surface and possibly altering the dielectric constant and band gap to increase device performance.

**31. R. L. Mills, J. Sankar, A. Voigt, J. He, B. Dhandapani, "Synthesis of HDLC Films from Solid Carbon", Thin Solid Films, submitted.**

Diamond-like carbon (DLC) films were synthesized on silicon substrates from solid carbon by a very low power (~60 W) microwave plasma chemical vapor deposition (MPCVD) reaction of a mixture of 90-70% helium and 10-30% hydrogen. It is proposed that  $\text{He}^+$  served as a catalyst with atomic hydrogen to form an energetic plasma. The average hydrogen atom temperature of a helium-hydrogen plasma was measured to be 180-210 eV versus  $\approx 3$  eV for pure hydrogen. Bombardment of the carbon surface by highly energetic hydrogen formed by the catalysis reaction may play a role in the formation of DLC. The films

were characterized by time of flight secondary ion mass spectroscopy (ToF-SIMS), X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), and Raman spectroscopy (Charles Evans & Associates, Sunnyvale, CA). TOF-SIMS identified the coatings as hydride by the large  $H^+$  peak in the positive spectrum and the dominant  $H^-$  in the negative spectrum. The XPS identification of the  $H$  content of the  $CH$  coatings as a novel hydride corresponding to a peak at 49 eV has implications that the mechanism of the DLC formation may also involve one or both of selective etching of graphitic carbon and the stabilization of  $sp^3$ -bonded carbon by the hydrogen catalysis product. Thus, a novel  $H$  intermediate formed by the plasma catalysis reaction may enhance the stabilization and etching role of  $H$  used in past methods.

30. **R. L. Mills, J. He, P. Ray, B. Dhandapani, X. Chen, "Synthesis and Characterization of a Highly Stable Amorphous Silicon Hydride as the Product of a Catalytic Helium-Hydrogen Plasma Reaction", Int. J. Hydrogen Energy, in press.**

A novel highly stable surface coating  $SiH(1/p)$  which comprised high binding energy hydride ions was synthesized by a microwave plasma reaction of a mixture of silane, hydrogen, and helium wherein it is proposed that  $He^+$  served as a catalyst with atomic hydrogen to form the highly stable hydride ions. Novel silicon hydride was identified by time of flight secondary ion mass spectroscopy and X-ray photoelectron spectroscopy. The time of flight secondary ion mass spectroscopy (ToF-SIMS) identified the coatings as hydride by the large  $SiH^+$  peak in the positive spectrum and the dominant  $H^-$  in the negative spectrum. X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA) identified the  $H$  content of the  $SiH$  coatings as hydride ions,  $H^-(1/4)$ ,  $H^-(1/9)$ , and  $H^-(1/11)$  corresponding to peaks at 11, 43, and 55 eV, respectively. The silicon hydride surface was remarkably stable to air as shown by XPS. The highly stable amorphous silicon hydride coating may advance the production of integrated circuits and microdevices by resisting the oxygen passivation of the surface and possibly altering the dielectric constant and band gap to increase device performance.

The plasma which formed  $SiH(1/p)$  showed a number of extraordinary features. Novel emission lines with energies of  $q \cdot 13.6 \text{ eV}$  where  $q = 1, 2, 3, 4, 6, 7, 8, 9, \text{ or } 11$  were previously observed by extreme ultraviolet (EUV) spectroscopy recorded on microwave discharges of helium with 2% hydrogen [R. Mills, P. Ray, "Spectral Emission of Fractional Quantum Energy Levels of Atomic Hydrogen from a Helium-Hydrogen Plasma and the Implications for Dark Matter", Int. J. Hydrogen Energy, Vol. 27, No. 3, pp. 301-322]. These

lines matched  $H(1/p)$ , fractional Rydberg states of atomic hydrogen where  $p$  is an integer, formed by a resonant nonradiative energy transfer to  $He^+$  acting as a catalyst. The average hydrogen atom temperature of the helium-hydrogen plasma was measured to be 180-210 eV versus  $\approx 3$  eV for pure hydrogen. Using water bath calorimetry, excess power was observed from the helium-hydrogen plasma compared to control krypton plasma. For example, for an input of 8.1 W, the total plasma power of the helium-hydrogen plasma measured by water bath calorimetry was 30.0 W corresponding to 21.9 W of excess power in  $3\text{ cm}^3$ . The excess power density and energy balance were high,  $7.3\text{ W/cm}^3$  and  $-2.9 \times 10^4\text{ kJ/mole H}_2$ , respectively. This catalytic plasma reaction may represent a new hydrogen energy source and a new field of hydrogen chemistry.

**29. R. L. Mills, A. Voigt, B. Dhandapani, J. He, "Synthesis and Characterization of Lithium Chloro Hydride", Int. J. Hydrogen Energy, submitted.**

A novel inorganic hydride compound lithium chloro hydride,  $LiHCl$ , which comprises a high binding energy hydride ion was synthesized by reaction of atomic hydrogen with potassium metal and lithium chloride. Lithium chloro hydride was identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA),  $^1H$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL), and powder X-ray diffraction (IC Laboratories, Amawalk, NY). Hydride ions with increased binding energies may form many novel compounds with broad applications such as the oxidant of a high voltage battery.

**28. R. Mills, E. Dayalan, P. Ray, B. Dhandapani, J. He, "Highly Stable Novel Inorganic Hydrides from Aqueous Electrolysis and Plasma Electrolysis", Electrochimica Acta, Vol. 47, No. 24, (2002), pp. 3909-3926.**

After  $10^4$  hours of continuous aqueous electrolysis with  $K_2CO_3$  as the electrolyte, highly stable novel inorganic hydride compounds such as  $KHKHCO_3$  and  $KH$  were isolated and identified by time of flight secondary ion mass spectroscopy (ToF-SIMS) (Charles Evans East, East Windsor, NJ). The existence of novel hydride ions was determined using X-ray photoelectron spectroscopy (XPS) (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA) and solid state magic-angle spinning  $^1H$  nuclear magnetic resonance spectroscopy ( $^1H$  MAS NMR) (Spectral Data Services, Inc., Champaign, IL). A novel ion formed by plasma electrolysis of a  $K_2CO_3$ ,  $Rb_2CO_3$ , or  $Cs_2CO_3$



electrolyte was also observed by high resolution visible spectroscopy at 407.0 nm corresponding to its predicted binding energy of 3.05 eV.

27. R. Mills, B. Dhandapani, M. Nansteel, J. He, A. Voigt, "Identification of Compounds Containing Novel Hydride Ions by Nuclear Magnetic Resonance Spectroscopy", Int. J. Hydrogen Energy, Vol. 26, No. 9, Sept. (2001), pp. 965-979.

Novel inorganic alkali and alkaline earth hydrides of the formula  $MH^*$ ,  $MH_2^*$ , and  $MH^*X$  wherein  $M$  is the metal,  $X$ , is a halide, and  $H^*$  comprises a novel high binding energy hydride ion were synthesized in a high temperature gas cell by reaction of atomic hydrogen with a catalyst and  $MH$ ,  $MH_2$ , or  $MX$  corresponding to an alkali metal or alkaline earth metal compound, respectively. Novel hydride ions of the corresponding novel hydride compounds were characterized by an extraordinary upfield shifted peak observed by  $^1H$  nuclear magnetic resonance spectroscopy. The result were confirmed on five different instruments at five independent laboratories (Spectral Data Services, Inc., Champaign, IL, National Research Council of Canada, University of Massachusetts Amherst, Amherst, MA, University of Delaware, Wilmington, DE, and Grace Davison, Columbia, MD).

26. R. Mills, B. Dhandapani, N. Greenig, J. He, "Synthesis and Characterization of Potassium Iodo Hydride", Int. J. of Hydrogen Energy, Vol. 25, Issue 12, December, (2000), pp. 1185-1203.

A novel inorganic hydride compound  $KHI$  which comprises a high binding energy hydride ion was synthesized by reaction of atomic hydrogen with potassium metal and potassium iodide. Potassium iodo hydride was identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA),  $^1H$  and  $^{39}K$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL), Fourier transform infrared spectroscopy (Surface Science Laboratories, Mountain View, CA), electrospray ionization time of flight mass spectroscopy (Perkin-Elmer Biosystems, Framingham, MA), liquid chromatography/mass spectroscopy (Ricerca, Inc., Painesville, Ohio), thermal decomposition with analysis by gas chromatography, and mass spectroscopy, and elemental analysis (Galbraith Laboratories, Inc., Knoxville, TN). Hydride ions with increased binding energies may form many novel compounds with broad applications.

25. R. Mills, "Novel Inorganic Hydride", Int. J. of Hydrogen Energy, Vol. 25, (2000), pp. 669-683.



A novel inorganic hydride compound  $KHKHCO_3$ , which is stable in water and comprises a high binding energy hydride ion was isolated following the electrolysis of a  $K_2CO_3$  electrolyte. Inorganic hydride clusters  $K[KHKHCO_3]^+$  were identified by Time of Flight Secondary Ion Mass Spectroscopy (Charles Evans East, East Windsor, NJ). Moreover, the existence of a novel hydride ion has been determined using X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), and  $^1H$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL). Hydride ions with increased binding energies may be the basis of a high voltage battery for electric vehicles.

24. R. Mills, B. Dhandapani, M. Nansteel, J. He, T. Shannon, A. Echezuria, "Synthesis and Characterization of Novel Hydride Compounds", Int. J. of Hydrogen Energy, Vol. 26, No. 4, (2001), pp. 339-367.

Novel inorganic alkali and alkaline earth hydrides of the formula  $MHX$  and  $MHMX$  wherein  $M$  is the metal,  $X$ , is a singly negatively charged anion, and  $H$  comprises a novel high binding energy hydride ion were synthesized in a high temperature gas cell by reaction of atomic hydrogen with a catalyst and  $MX$  or  $MX_2$  corresponding to an alkali metal or alkaline earth metal, respectively. It has been reported that intense extreme ultraviolet (EUV) emission was observed at low temperatures (e.g.  $\approx 10^3 K$ ) from atomic hydrogen and certain atomized elements or certain gaseous ions which ionize at integer multiples of the potential energy of atomic hydrogen, 27.2 eV [1-5]. These atomized elements or certain gaseous ions comprised the catalyst to form  $MHX$  and  $MHMX$ . For example, atomic hydrogen was reacted with strontium vapor and  $SrBr_2$  to form  $SrHBr$ . Novel hydride compounds such as  $SrHBr$  were identified by time of flight secondary ion mass spectroscopy, X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA),  $^1H$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL), and thermal decomposition with analysis by gas chromatography, and mass spectroscopy. Hydride ions with increased binding energies form novel compounds with potential broad applications such as a high voltage battery for consumer electronics and electric vehicles. In addition, these novel compositions of matter and associated technologies may have far-reaching applications in many industries including chemical, electronics, computer, military, energy, and aerospace in the form of products such as propellants, solid fuels, surface coatings, structural materials, and chemical processes.

**23. R. Mills, "Highly Stable Novel Inorganic Hydrides", Journal of New Materials for Electrochemical Systems, Vol. 6, (2003), pp. 45-54.**

Novel inorganic hydride compounds  $KHKHCO_3$  and  $KH$  were isolated following the electrolysis of a  $K_2CO_3$  electrolyte. The compounds which comprised high binding energy hydride ions were stable in water, and  $KH$  was stable at elevated temperature (600 °C). Inorganic hydride clusters  $K[KHKHCO_3]^+$  were identified by positive Time of Flight Secondary Ion Mass Spectroscopy (ToF-SIMS) of  $KHKHCO_3$  (Charles Evans East, East Windsor, NJ). The negative ToF-SIMS was dominated by hydride ion. The positive and negative ToF-SIMS of  $KH$  showed essentially  $K^+$  and  $H^-$  only, respectively. Moreover, the existence of novel hydride ions was determined using X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), and  $^1H$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL). Hydride ions with increased binding energies may be the basis of a high voltage battery for electric vehicles.

**22. R. Mills, "Novel Hydrogen Compounds from a Potassium Carbonate Electrolytic Cell", Fusion Technology, Vol. 37, No. 2, March, (2000), pp. 157-182.**

Novel compounds containing hydrogen in new hydride and polymeric states which demonstrate novel hydrogen chemistry have been isolated following the electrolysis of a  $K_2CO_3$  electrolyte with the production of excess energy. Inorganic hydride clusters  $K[KHKHCO_3]^+$  and hydrogen polymer ions such as  $OH_{23}^+$  and  $H_{16}^-$  were identified by time of flight secondary ion mass spectroscopy (Charles Evans East, East Windsor, NJ). The presence of compounds containing new states of hydrogen were confirmed by X-ray photoelectron spectroscopy (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA), X-ray diffraction, Fourier transform infrared spectroscopy (Surface Science Laboratories, Mountain View, CA), Raman spectroscopy (Environmental Catalysis and Materials Laboratory of Virginia Polytechnic Institute), and  $^1H$  nuclear magnetic resonance spectroscopy (Spectral Data Services, Inc., Champaign, IL).

**21. Mills, R., Good, W., "Fractional Quantum Energy Levels of Hydrogen", Fusion Technology, Vol. 28, No. 4, November, (1995), pp. 1697-1719.**

Determination of excess heat release during the electrolysis of aqueous potassium carbonate by the very accurate and reliable method of heat measurement, flow calorimetry; describes the experimental identification of hydrogen atoms in fractional quantum energy levels—hydrinos—by X-ray Photoelectron Spectroscopy (XPS) (Zettlemoyer Center for

Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA); describes the experimental identification of hydrogen atoms in fractional quantum energy levels—hydrinos—by emissions of soft X-rays from dark matter; describes the experimental identification of hydrogen molecules in fractional quantum energy levels—dihydrino—molecules by high resolution magnetic sector mass spectroscopy with ionization energy determination, and gives a summary.

In summary:

Excess power and heat were observed during the electrolysis of aqueous potassium carbonate. Flow calorimetry of pulsed current electrolysis of aqueous potassium carbonate at a nickel cathode was performed in a single-cell dewar. The average power out of 24.6 watts exceeded the average input power (voltage times current) of 4.73 watts by a factor greater than 5. The total input energy (integration of voltage times current) over the entire duration of the experiment was 5.72 MJ; whereas, the total output energy was 29.8 MJ. No excess heat was observed when the electrolyte was changed from potassium carbonate to sodium carbonate. The source of heat is assigned to the electrocatalytic, exothermic reaction whereby the electrons of hydrogen atoms are induced to undergo transitions to quantized energy levels below the conventional "ground state". These lower energy states correspond to fractional quantum numbers:  $n = 1/2, 1/3, 1/4, \dots$ . Transitions to these lower energy states are stimulated in the presence of pairs of potassium ions ( $K^+/K^+$  electrocatalytic couple) which provide 27.2 eV energy sinks.

The identification of the  $n = 1/2$  hydrogen atom,  $H(n = 1/2)$  is reported. Samples of the nickel cathodes of aqueous potassium carbonate electrolytic cells and aqueous sodium carbonate electrolytic cells were analyzed by XPS (Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA). A broad peak centered at 54.6 eV was present only in the cases of the potassium carbonate cells. The binding energy (in vacuum) of  $H(n = 1/2)$  is 54.4 eV. Thus, the theoretical and measured binding energies for  $H(n = 1/2)$  are in excellent agreement.

Further experimental identification of hydrinos—down to  $H(n = 1/8)$ —can be found in the alternative explanation by Mills et al. for the soft X-ray emissions of the dark interstellar medium observed by Labov and Bowyer [Labov, S., Bowyer, S., "Spectral observations of the extreme ultraviolet background", The Astrophysical Journal, 371, (1991), pp. 810-819] of the Extreme UV Center of the University of California, Berkeley. The agreement between the experimental spectrum and the energy values predicted for the proposed transitions is remarkable.

The reaction product of two  $H(n=1/2)$  atoms, the dihydrino molecule, was identified by mass spectroscopy (Shrader Analytical & Consulting Laboratories). The mass spectrum of the cryofiltered gases evolved during the electrolysis of a light water  $K_2CO_3$  electrolyte with a nickel cathode demonstrated that the dihydrino molecule,  $H_2\left(n=\frac{1}{2}\right)$ , has a higher ionization energy, about 63 eV, than normal molecular hydrogen,  $H_2(n=1)$ , 15.46 eV. The high resolution (0.001 AMU) magnetic sector mass spectroscopic analysis of the postcombustion gases indicated the presence of two peaks of nominal mass two-- one peak at 70 eV and one peak at 25 eV. The same analysis of molecular hydrogen indicates only one peak at 25 eV and one peak at 70 eV. In the case of the postcombustion sample at 70 eV, one peak was assigned as the hydrogen molecular ion peak,  $H_2^+(n=1)$ , and one peak was assigned as the dihydrino molecular peak,  $H_2^+\left(n=\frac{1}{2}\right)$  which has a slightly larger magnetic moment.

**20. Mills, R., Good, W., Shaubach, R., "Dihydrino Molecule Identification", Fusion Technology, Vol. 25, 103 (1994).**

Calorimetry of pulsed current and continuous electrolysis of aqueous potassium carbonate ( $K^+/K^+$  electrocatalytic couple) at a nickel cathode was performed by Thermacore, Inc., Lancaster, PA. The excess power out of 41 watts exceeded the total input power given by the product of the electrolysis voltage and current by a factor greater than 8. Elemental analysis of the electrolyte and metallurgical analysis of the cathode showed no evidence of chemical reactions. The pH, specific gravity, concentration of  $K_2CO_3$ , and the elemental analysis of the electrolyte sample taken after 42 days of continuous operation were unchanged from that of the values obtained for the electrolyte sample taken before operation. Elemental analysis and scanning electron microscopy of metallurgical samples of the nickel cathode taken before operation and at day 56 of continuous operation were identical indicating that the nickel cathode had not changed chemically or physically. Scintillation counter and photographic film measurements showed that no radiation above background was detected indicating that nuclear reactions did not occur.

The "ash" of the exothermic reaction is atoms having electrons of energy below the "ground state" which are predicted to form molecules. The predicted molecules were identified by lack of reactivity with oxygen, by separation from molecular deuterium by cryofiltration, and by mass spectroscopic analysis. The combustion of the gases evolved during the electrolysis of a light water  $K_2CO_3$  electrolyte ( $K^+/K^+$  electrocatalytic couple) with a nickel cathode was incomplete. The mass spectroscopic analysis (Dr. David Parees of Air



Products & Chemicals, Inc.) of the  $m/e = 2$  peak of the combusted gas demonstrated that the dihydrino molecule,  $H_2(n = 1/2)$ , has a higher ionization energy than  $H_2$ .

Calorimetry of pulsed current and continuous electrolysis of aqueous potassium carbonate ( $K^+/K^+$  electrocatalytic couple) at a nickel cathode was performed in single cell dewar calorimetry cells by HydroCatalysis Power Corporation. Excess power out exceeded input power by a factor greater than 16. No excess heat was observed when the electrolyte was changed from potassium carbonate to the control sodium carbonate. The faraday efficiency was measured volumetrically to be 100%.

**19. V. Noninski, Fusion Technol., Vol. 21, 163 (1992).**

Dr. Noninski of the Laboratory for Electrochemistry of Renewed Electrode-Solution Interface (LEPGER) successfully reproduced the results of Mills and Kneizys [R. Mills and S. Kneizys, Fusion Technol. Vol. 20, 65 (1991)] as a visiting professor at Franklin and Marshall College. A significant increase in temperature with every watt input, compared with the calibration experiment ( $\approx 50^\circ C/W$  versus  $\approx 30^\circ C/W$ ), was observed during the electrolysis of potassium carbonate. This effect was not observed when sodium carbonate was electrolyzed. No trivial explanation (in terms of chemical reactions, change in heat transfer properties, etc.) of this effect were found.

**18. Niedra, J., Meyers, I., Fralick, G. C., and Baldwin, R., "Replication of the Apparent Excess Heat Effect in a Light Water-Potassium Carbonate-Nickel Electrolytic Cell, NASA Technical Memorandum 107167, February, (1996). pp. 1-20.; Niedra, J., Baldwin, R., Meyers, I., NASA Presentation of Light Water Electrolytic Tests, May 15, 1994.**

NASA Lewis tested a cell identical to that of Thermacore [Mills, R., Good, W., Shaubach, R., "Dihydrino Molecule Identification", Fusion Technology, Vol. 25, 103 (1994)] with the exception that it was minus the central cathode. A cell identical to the test cell with heater power only (no electrolysis) was the calibration control and the blank cell with the heater power equal to zero. The test cell was also calibrated "on the fly" by measuring the temperature relative to the blank cell at several values of heater input power of the test cell. "Replication of experiments claiming to demonstrate excess heat production in light water-Ni- $K_2CO_3$  electrolytic cells was found to produce an apparent excess heat of 11 W maximum, for 60 W electrical power into the cell. Power gains ranged from 1.06 to 1.68." The production of excess energy with a power gain of 1.68 would require 0% Faraday efficiency to account for the observed excess power.

↑ power gain  
in conclusion



**17. Technology Insights, 6540 Lusk Boulevard, Suite C-102, San Diego, CA 92121,  
"HydroCatalysis Technical Assessment Prepared for PacifiCorp", August 2, 1996.**

This report documents a technical assessment of a novel source of hydrogen energy advanced by HydroCatalysis Power Corporation now BlackLight Power, Inc. (BLP). The assessment was conducted as part of the due diligence performed for PacifiCorp. It was conducted by a literature search and review, site visits to BLP and collaborating organizations, and telephone interviews with others active in the general area. A description of concept is provided in Section 3. Section 4 presents an assessment of the concept background, supporting theory, laboratory prototypes, projected initial products, and economic and environmental aspects. Section 5 documents the results of telephone interviews and site visits. An overall summary and conclusions are presented in the following section.

**16. P. M. Jansson, "HydroCatalysis: A New Energy Paradigm for the 21st Century",  
Thesis Submitted in partial fulfillment of the requirements of the Masters of  
Science in Engineering Degree in the Graduate Division of Rowan University, May  
1997, Thesis Advisors: Dr. J. L. Schmalzel, Dr. T. R. Chandrupatla, and Dr. A. J.  
Marchese, External Advisors: Dr. J. Phillips, Pennsylvania State University, Dr. R.  
L. Mills, BlackLight Power, Inc., W. R. Good, BlackLight Power, Inc.**

This thesis reviews the problems of worldwide energy supply, describes the current technologies that meet the energy needs of our industrial societies, summarizes the environmental impacts of those fuels and technologies and their increased use by a growing global and increasing technical economy. The work also describes and advances the technology being developed by BlackLight Power, Inc. (BLP) a scientific company located in Princeton, New Jersey. BLP's technology proports to offer commercially viable and useful heat generation via a previously unrecognized natural phenomenon - the catalytic reduction of the hydrogen atom to a lower energy state. Laboratory tests obtained as original research of this thesis as well as the review of the data of others substantiate the fact that replication of the experimental conditions which are favorable to initiating and sustaining the new energy release process will generate controllable, reproducible, sustainable and commercial meaningful heat. For example, Jansson has determined heat production associated with hydrino formation with a Calvet calorimeter which yielded exceptional results. Specifically, the results are completely consistent with Mills hydrino formation hypothesis. Approximately  $10^{-3}$  moles of hydrogen was admitted to a 20  $cm^3$  Calvet cell containing a heated platinum

filament and  $KNO_3$  powder. In the three separate trials with a platinum filament hydrogen dissociator which was varied in length of 10 cm, 20 cm, and 30 cm, a mean power of 0.581, 0.818, and 1.572 watts was observed, respectively. The closed experiments were run to completion. The energy observed was 622, 369, and 747 kJ, respectively. This is equivalent to the generation of  $6.2 \times 10^8 \text{ J/mole}$ ,  $3.7 \times 10^8 \text{ J/mole}$ , and  $7.5 \times 10^8 \text{ J/mole}$  of hydrogen, respectively, as compared to  $2.5 \times 10^5 \text{ J/mole}$  of hydrogen anticipated for standard hydrogen combustion. Thus, the total heats generated appear to be at least 1000 times too large to be explained by conventional chemistry, but the results are completely consistent with Mills model. Convincing evidence is presented to lead to the conclusion that BLP technology has tremendous potential to achieve commercialization and become an energy paradigm for the next century. The research was also conducted as part of the due diligence performed for Atlantic Energy now Conectiv.

15. Phillips, J., Smith, J., Kurtz, S., "Report On Calorimetric Investigations Of Gas-Phase Catalyzed Hydrino Formation" Final report for Period October-December 1996", January 1, 1997, A Confidential Report submitted to BlackLight Power, Inc. provided by BlackLight Power, Inc., Great Valley Corporate Center, 41 Great Valley Parkway, Malvern, PA 19355.

Pennsylvania State University Chemical Engineering Department has determined heat production associated with hydrino formation with a Calvet calorimeter which yielded exceptional results. Specifically, the results are completely consistent with Mills hydrino formation hypothesis. In three separate trials, between 10 and 20 K Joules were generated at a rate of 0.5 Watts, upon admission of approximately  $10^{-3}$  moles of hydrogen to the  $20 \text{ cm}^3$  Calvet cell containing a heated platinum filament and  $KNO_3$  powder. This is equivalent to the generation of  $10^7 \text{ J/mole}$  of hydrogen, as compared to  $2.5 \times 10^5 \text{ J/mole}$  of hydrogen anticipated for standard hydrogen combustion. Thus, the total heats generated appear to be 100 times too large to be explained by conventional chemistry, but the results are completely consistent with Mills model.

14. Phillips, J., Shim, H., "Additional Calorimetric Examples of Anomalous Heat from Physical Mixtures of K/Carbon and Pd/Carbon", January 1, 1996, A Confidential Report submitted to HydroCatalysis Power Corporation provided by HydroCatalysis Power Corporation, Great Valley Corporate Center, 41 Great Valley Parkway, Malvern, PA 19355.

Pennsylvania State University Chemical Engineering Department has determined excess heat release from flowing hydrogen in the presence of ionic hydrogen spillover catalytic material: 40% by weight potassium nitrate ( $\text{KNO}_3$ ) on graphitic carbon powder with 5% by weight 1%-Pd-on-graphitic carbon ( $\text{K}^+/\text{K}^+$  electrocatalytic couple) by the very accurate and reliable method of heat measurement, thermopile conversion of heat into an electrical output signal. Excess power and heat were observed with flowing hydrogen over the catalyst. However, no excess power was observed with flowing helium over the catalyst mixture. Rates of heat production were reproducibly observed which were higher than that expected from the conversion of all the hydrogen entering the cell to water, and the total energy observed was over four times larger than that expected if all the catalytic material in the cell were converted to the lowest energy state by "known" chemical reactions. Thus, "anomalous" heat, heat of a magnitude and duration which could not be explained by conventional chemistry, was reproducibly observed.

13. **Bradford, M. C., Phillips, J., "A Calorimetric Investigation of the Reaction of Hydrogen with Sample PSU #1", September 11, 1994, A Confidential Report submitted to HydroCatalysis Power Corporation provided by HydroCatalysis Power Corporation, Great Valley Corporate Center, 41 Great Valley Parkway, Malvern, PA 19355.**

Pennsylvania State University Chemical Engineering Department has determined excess heat release from flowing hydrogen in the presence of nickel oxide powder containing strontium niobium oxide ( $\text{Nb}^{3+}/\text{Sr}^{2+}$  electrocatalytic couple) by the very accurate and reliable method of heat measurement, thermopile conversion of heat into an electrical output signal. Excess power and heat were observed with flowing hydrogen over the catalyst which increased with increasing flow rate. However, no excess power was observed with flowing helium over the catalyst/nickel oxide mixture or flowing hydrogen over nickel oxide alone. Approximately 10 cc of nickel oxide powder containing strontium niobium oxide immediately produced 0.55 W of steady state output power at 523 K. When the gas was switched from hydrogen to helium, the power immediately dropped. The switch back to hydrogen restored the excess power output which continued to increase until the hydrogen source cylinder emptied at about the 40,000 second time point. With no hydrogen flow the output power fell to zero.

The source of heat is assigned to the electrocatalytic, exothermic reaction whereby the electrons of hydrogen atoms are induced to undergo transitions to quantized energy levels below the conventional "ground state". These lower energy states correspond to

fractional quantum numbers:  $n = 1/2, 1/3, 1/4, \dots$ . Transitions to these lower energy states are stimulated in the presence of pairs of niobium and strontium ions ( $\text{Nb}^{3+}/\text{Sr}^{2+}$  electrocatalytic couple) which provide 27.2 eV energy sinks.

12. Jacox, M. G., Watts, K. D., "The Search for Excess Heat in the Mills Electrolytic Cell", Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, 83415, January 7, 1993.

Idaho National Engineering Laboratory (INEL) operated a cell identical to that of Thermacore [Mills, R., Good, W., Shaubach, R., "Dihydrino Molecule Identification", Fusion Technology, Vol. 25, 103 (1994)] except that it was minus the central cathode and that the cell was wrapped in a one-inch layer of urethane foam insulation about the cylindrical surface. The cell was operated in a pulsed power mode. A current of 10 amperes was passed through the cell for 0.2 seconds followed by 0.8 seconds of zero current for the current cycle. The cell voltage was about 2.4 volts, for an average input power of 4.8 W. The electrolysis power average was 1.84 W, and the stirrer power was measured to be 0.3 W. Thus, the total average net input power was 2.14 W. The cell was operated at various resistance heater settings, and the temperature difference between the cell and the ambient as well as the heater power were measured. The results of the excess power as a function of cell temperature with the cell operating in the pulsed power mode at 1 Hz with a cell voltage of 2.4 volts, a peak current of 10 amperes, and a duty cycle of 20 % showed that the excess power is temperature dependent for pulsed power operation, and the maximum excess power was 18 W for an input electrolysis joule heating power of 2.14 W. Thus, the ratio of excess power to input electrolysis joule heating power was 850 %. INEL scientists constructed an electrolytic cell comprising a nickel cathode, a platinized titanium anode, and a 0.57 M  $\text{K}_2\text{CO}_3$  electrolyte. The cell design appears in Appendix 1. The cell was operated in the environmental chamber in the INEL Battery Test Laboratory at constant current, and the heat was removed by forced air convection in two cases. In the first case, the air was circulated by the environmental chamber circulatory system alone. In the second case, an additional forced air fan was directed onto the cell. The cell was equipped with a water condenser, and the water addition to the cell due to electrolysis losses was measured. The data of the forced convection heat loss calorimetry experiments during the electrolysis of a 0.57 M  $\text{K}_2\text{CO}_3$  electrolyte with the INEL cell showed that 13 W of excess power was produced. This excess power could not be attributed to recombination of the hydrogen and oxygen as indicated by the equivalence of the calculated and measured water balance.



11. **Peterson, S., H., Evaluation of Heat Production from Light Water Electrolysis Cells of HydroCatalysis Power Corporation, Report from Westinghouse STC, 1310 Beulah Road, Pittsburgh, PA, February 25, 1994.**

Westinghouse Electric Corporation reports that excess heat was observed during the electrolysis of aqueous potassium carbonate ( $K^+/K^+$  electrocatalytic couple) where the electrolysis of aqueous sodium carbonate served as the control. The data of the temperature of the cell minus the ambient temperature shows that when potassium carbonate replaced sodium carbonate in the same cell with the same input electrolysis power, the potassium experiment was twice as hot as the sodium carbonate experiment for the duration of the experiment, one month. The net faraday efficiency of gas evolution was experimentally measured to be unity by weighing the experiment to determine that the expected rate of water consumption was observed. The output power exceeded the total input power. The data was analyzed by HydroCatalysis Power Corporation [Mills, R., Analysis by HydroCatalysis Power Corporation of Westinghouse Report Entitled "Evaluation of Heat Production from Light Water Electrolysis Cells of HydroCatalysis Power Corporation, Report from Westinghouse STC", February 25, 1994].

10. **Haldeman, C. W., Savoye, G. W., Iseler, G. W., Clark, H. R., MIT Lincoln Laboratories Excess Energy Cell Final report ACC Project 174 (3), April 25, 1995.**

During the electrolysis of aqueous potassium carbonate, researchers working at MIT Lincoln Laboratories observed long duration excess power of 1-5 watts with output/input ratios over 10 in some cases with respect to the cell input power reduced by the enthalpy of the generated gas. In these cases, the output was 1.5 to 4 times the integrated volt-ampere power input. Faraday efficiency was measured volumetrically by direct water displacement.

9. **Craw-Ivanco, M. T.; Tremblay, R. P.; Boniface, H. A.; Hilborn, J. W.; "Calorimetry for a  $Ni/K_2CO_3$  Cell", Atomic Energy Canada Limited, Chemical Engineering Branch, Chalk River Laboratories, Chalk River, Ontario, June 1994.**

Atomic Energy Canada Limited, Chalk River Laboratories, report that 128 % and 138% excess heat were observed in separate experiments by flow calorimetry during the electrolysis of aqueous potassium carbonate ( $K^+/K^+$  electrocatalytic couple) in a closed cell, and that 138% was observed in an open cell.

8. **Shaubach, R. M., Gernert, N. J., "Anomalous Heat From Hydrogen in Contact with Potassium Carbonate", Thermacore Report, March 1994.**



A high temperature/high pressure/high power density industrial prototype gas cell power generator which produced 50 watts of power at 300 °C having a nickel surface area of only 300 cm<sup>2</sup> was successfully developed. A sample of the nickel tubing of the aqueous potassium carbonate permeation cell was analyzed by XPS at the Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA. A broad peak centered at 54.6 eV was present; whereas, the control nickel tube showed no feature. The binding energy (in vacuum) of H(n = 1/2) is 54.4 eV. Thus, the theoretical and measured binding energies for H(n = 1/2) are in excellent agreement. No excess energy or 54.6 eV feature were observed when sodium carbonate replaced potassium carbonate.

7. **Gernert, N., Shaubach, R. M., Mills, R., Good, W., "Nascent Hydrogen: An Energy Source," Final Report prepared by Thermacore, Inc., for the Aero Propulsion and Power Directorate, Wright Laboratory, Air Force Material Command (ASC), Wright-Patterson Air Force Base, Contract Number F33615-93-C-2326, May, (1994).**

In a report prepared for the Aero Propulsion and Power Directorate, Wright Laboratory, Air Force Material Command (ASC), Wright-Patterson Air Force Base, Thermacore reports, "anomalous heat was observed from a reaction of atomic hydrogen in contact with potassium carbonate on a nickel surface. The nickel surface consisted of 500 feet of 0.0625 inch diameter tubing wrapped in a coil. The coil was inserted into a pressure vessel containing a light water solution of potassium carbonate. The tubing and solution were heated to a steady state temperature of 249 °C using an I<sup>2</sup>R heater. Hydrogen at 1100 psig was applied to the inside of the tubing. After the application of hydrogen, a 32 °C increase in temperature of the cell was measured which corresponds to 25 watts of heat. Heat production under these conditions is predicted by the theory of Mills where a new species of hydrogen is produced that has a lower energy state than normal hydrogen. ESCA analysis, done independently by Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA, have found the predicted 55 eV signature of this new species of hydrogen."

6. **Wiesmann, H., Brookhaven National Laboratory, Department of Applied Science, Letter to Dr. Walter Polansky of the Department of Energy Regarding Excess Energy Verification at Brookhaven National Laboratory, October 16, 1991.**

Calorimetry of continuous electrolysis of aqueous potassium carbonate (K<sup>+</sup>/K<sup>+</sup> electrocatalytic couple) at a nickel cathode was performed in single cell dewar calorimetry cell by Noninski at Brookhaven National Laboratory. Dr. Weismann observed the experiment

and reported the results to Dr. Walter Polansky of the U. S. Department of Energy. Dr. Weismann reports, "The claim is as follows. The temperature rise in the dewar is greater in the case of electrolysis as compared to using a resistor, even though the power dissipated is equal in both cases. According to Dr. Mills' theory, this apparent "excess power" is due to the fact that the electron in a hydrogen atom can "decay" to stable subinterger quantum levels. Dr. Noninski demonstrated this thermal effect at BNL." The observed rise in temperature for a given input power was twice as high comparing electrolysis versus heater power.

**5. Nesterov, S. B., Kryukov, A. P., Moscow Power Engineering Institute Affidavit, February, 26, 1993.**

The Moscow Power Engineering Institute experiments showed 0.75 watts of heat output with only 0.3 watts of total power input (power = VI) during the electrolysis of an aqueous potassium carbonate electrolyte with a nickel foil cathode and a platinized titanium anode. Excess power over the total input on the order of 0.45 watts was produced reliably and continuously over a period of three months. Evaluation of the electrolyte after three months of operation showed no significant change in its density or molar concentration. The cell was disassembled and inspected after over one month of operation at 0.1 amperes. This inspection showed no visible signs of a reaction between the electrodes and the electrolyte. The cell was re-assembled and operated as before. Excess energy was produced for the three month duration of the experiment. Scintillation counter measurements showed no signs of radiation external to the cell.

**4. Miller, A., Simmons, G., Lehigh X-Ray Photoelectron Spectroscopy Report, Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University Bethlehem, PA, November 1993.**

Samples of the nickel cathodes of aqueous potassium carbonate electrolytic cells and aqueous sodium carbonate electrolytic cells were analyzed by XPS by Miller and Simmons of the Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA. A broad peak centered at 54.6 eV was present only in the cases of the potassium carbonate cells. The binding energy (in vacuum) of H(n = 1/2) is 54.4 eV. Thus, the theoretical and measured binding energies for H(n = 1/2) are in excellent agreement. Lehigh University has conducted an extensive investigation of the cathodes from heat producing as well as those from control cells. Miller concludes that "I was unable to find any other elements on the surface that cause the feature. The persistent appearance of a

spectral feature near the predicted binding energy for many of the electrodes used with a K electrolyte is an encouraging piece of evidence for the existence of the reduced energy state hydrogen".

**3. Jacox, M. G., Watts, K. D., "INEL XPS Report", Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, 83415, November 1993.**

The Lehigh XPS results of a broad peak centered at 54.6 eV present only in the cases of the potassium carbonate cells [Miller, A., Simmons, G., Lehigh X-Ray Photoelectron Spectroscopy Report, Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA, November 1993] were confirmed at Idaho National Engineering Laboratory (INEL). Samples which demonstrated the feature as well as control electrodes were tested for the presence of trace amounts of impurities of the elements iron and lithium at a sensitivity level of greater than 1000 times that of XPS. TOF-SIMS (Time of Flight-Secondary Ion Mass Spectroscopy) and XPS analysis of the nickel surface was performed by Charles Evans & Associates, Sunnyvale, CA [Lee, Jang-Jung, Charles Evans & Associates Time-Of-Flight Secondary Ion Mass Spectroscopy (TOF-SIMS) Surface Analysis Report, CE&A Number 40150, March 18, 1994]. The 54.6 eV feature was also observed by Charles Evans & Associates in the case of cathodes of potassium carbonate electrolytic cells [Craig, A., Y., Charles Evans & Associates XPS/ESCA Results, CE&A Number 44545, November 3, 1994]. Iron and lithium were the only remaining atoms which were in question by Lehigh University and INEL as the source of the 54.6 eV XPS peak. The Charles Evans TOF-SIMS results demonstrate that iron and lithium were not the source of this peak.

**2. Lee, Jang-Jung, Charles Evans & Associates Time-Of-Flight Secondary Ion Mass Spectroscopy (TOF-SIMS) Surface Analysis Report, CE&A Number 40150, March 18, 1994.**

The Lehigh XPS results of a broad peak centered at 54.6 eV present only in the cases of the potassium carbonate cells [Miller, A., Simmons, G., Lehigh X-Ray Photoelectron Spectroscopy Report, Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA, November 1993] were confirmed at Idaho National Engineering Laboratory (INEL) [Jacox, M. G., Watts, K. D., "INEL XPS Report", Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, 83415, November 1993]. Samples which demonstrated the feature as well as control electrodes were tested for the presence of trace amounts of impurities of the elements iron and lithium at a sensitivity level of greater than 1000 times that of XPS. TOF-SIMS (Time of Flight-Secondary Ion Mass

Spectroscopy) and XPS analysis of the nickel surface was performed by Charles Evans & Associates, Sunnyvale, CA. The 54.6 eV feature was also observed by Charles Evans & Associates in the case of cathodes of potassium carbonate electrolytic cells [Jacox, M. G., Watts, K. D., "INEL XPS Report", Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, 83415, November 1993]. Iron and lithium were the only remaining atoms which were in question by Lehigh University and INEL as the source of the 54.6 eV XPS peak. The Charles Evans TOF-SIMS results demonstrate that iron and lithium were not the source of this peak.

**1. Craig, A., Y., Charles Evans & Associates XPS/ESCA Results, CE&A Number 44545, November 3, 1994.**

The Lehigh XPS results of a broad peak centered at 54.6 eV present only in the cases of the potassium carbonate cells [Miller, A., Simmons, G., Lehigh X-Ray Photoelectron Spectroscopy Report, Zettlemoyer Center for Surface Studies, Sinclair Laboratory, Lehigh University, Bethlehem, PA, November 1993] were confirmed at Idaho National Engineering Laboratory (INEL) [Jacox, M. G., Watts, K. D., "INEL XPS Report", Idaho National Engineering Laboratory, EG&G Idaho, Inc., Idaho Falls, Idaho, 83415, November 1993]. Samples which demonstrated the feature as well as control electrodes were tested for the presence of trace amounts of impurities of the elements iron and lithium at a sensitivity level of greater than 1000 times that of XPS. TOF-SIMS (Time of Flight-Secondary Ion Mass Spectroscopy) and XPS analysis of the nickel surface was performed by Charles Evans & Associates, Sunnyvale, CA [Lee, Jang-Jung, Charles Evans & Associates Time-Of-Flight Secondary Ion Mass Spectroscopy (TOF-SIMS) Surface Analysis Report, CE&A Number 40150, March 18, 1994]. The 54.6 eV feature was also observed by Charles Evans & Associates in the case of cathodes of potassium carbonate electrolytic cells. Iron and lithium were the only remaining atoms which were in question by Lehigh University and INEL as the source of the 54.6 eV XPS peak. The Charles Evans TOF-SIMS results demonstrate that iron and lithium were not the source of this peak.

This independent, third-party experimental data conclusively proves the enablement and operability of Applicant's invention. Applicant is entitled to have this evidence accepted as reliable and to have this and other Blacklight applications issue as patents.

### Conclusion

For the foregoing reasons, Applicant respectfully submits that the subject application fully satisfies the legal requirements of 35 U.S.C. §§ 101 and 112, first paragraph, and is therefore in condition for allowance. A Notice to that affect is earnestly solicited.

Respectfully submitted,  
Manelli, Denison & Selter, PLLC

By

  
Jeffrey S. Melcher

Reg. No.: 35,950

Tel. No.: 202.261.1045

Fax. No.: 202.887.0336

Customer No. 20736



## LIST OF REFERENCES

94. R. L. Mills, "The Nature of the Chemical Bond Revisited and an Alternative Maxwellian Approach," J. Phys. D., submitted. (*Web Publication Date: Aug. 6, 2003.*)
93. R. L. Mills, P. Ray, M. Nansteel, J. He, X. Chen, A. Voigt, B. Dhandapani, "Energetic Catalyst-Hydrogen Plasma Reaction Forms a New State of Hydrogen," in preparation.
92. R. L. Mills, P. Ray, M. Nansteel, J. He, X. Chen, A. Voigt, B. Dhandapani, Luca Gamberale, "Energetic Catalyst-Hydrogen Plasma Reaction as a Potential New Energy Source," European Physical Journal D, submitted. (*Web Publication Date: June 6, 2003.*)
91. R. Mills, P. Ray, "New H I Laser Medium Based on Novel Energetic-Plasma of Atomic Hydrogen and Certain Group I Catalysts," J. Plasma Physics, submitted.
90. R. L. Mills, P. Ray, M. Nansteel, J. He, X. Chen, A. Voigt, B. Dhandapani, "Characterization of Energetic Catalyst-Hydrogen Plasma Reaction as a Potential New Energy Source," Am. Chem. Soc. Div. Fuel Chem. Prepr., Vol. 48, No. 2, (2003).
89. R. Mills, P. C. Ray, R. M. Mayo, M. Nansteel, W. Good, P. Jansson, B. Dhandapani, J. He, "Hydrogen Plasmas Generated Using Certain Group I Catalysts Show Stationary Inverted Lyman Populations and Free-Free and Bound-Free Emission of Lower-Energy State Hydride," Technical Physics, submitted.
88. R. Mills, J. Sankar, A. Voigt, J. He, P. Ray, B. Dhandapani, "Role of Atomic Hydrogen Density and Energy in Low Power CVD Synthesis of Diamond Films," JACS, in preparation.
87. R. Mills, B. Dhandapani, M. Nansteel, J. He, P. Ray, "Liquid-Nitrogen-Condensable Molecular Hydrogen Gas Isolated from a Catalytic Plasma Reaction," J. Phys. Chem. B, submitted.
86. R. L. Mills, P. Ray, J. He, B. Dhandapani, M. Nansteel, "Novel Spectral Series from Helium-Hydrogen Evenson Microwave Cavity Plasmas that Matched Fractional-Principal-Quantum-Energy-Level Atomic and Molecular Hydrogen," European Journal of Physics, submitted. (*Web Publication Date: April 24, 2003.*)
85. R. L. Mills, P. Ray, R. M. Mayo, "Highly Pumped Inverted Balmer and Lyman Populations," New Journal of Physics, submitted.
84. R. L. Mills, P. Ray, J. Dong, M. Nansteel, R. M. Mayo, B. Dhandapani, X. Chen, "Comparison of Balmer  $\alpha$  Line Broadening and Power Balances of Helium-Hydrogen Plasma Sources," Plasma Sources Science and Technology, submitted. (*Web Publication Date: March 12, 2003.*)

83. R. Mills, P. Ray, M. Nansteel, R. M. Mayo, "Comparison of Water-Plasma Sources of Stationary Inverted Balmer and Lyman Populations for a CW HI Laser," J. Appl. Spectroscopy, in preparation.
82. R. Mills, J. Sankar, P. Ray, J. He, A. Voigt, B. Dhandapani, "Synthesis and Characterization of Diamond Films from MPCVD of an Energetic Argon-Hydrogen Plasma and Methane," Materials Science, submitted. (*Web Publication Date: May 7, 2003.*)
81. R. Mills, P. Ray, B. Dhandapani, W. Good, P. Jansson, M. Nansteel, J. He, A. Voigt, "Spectroscopic and NMR Identification of Novel Hydride Ions in Fractional Quantum Energy States Formed by an Exothermic Reaction of Atomic Hydrogen with Certain Catalysts," European Physical Journal: Applied Physics, submitted. (*Web Publication Date: Feb. 21, 2003.*)
80. R. L. Mills, "The Fallacy of Feynman's Argument on the Stability of the Hydrogen Atom According to Quantum Mechanics," Foundations of Phys., submitted. (*Web Publication Date: Jan. 27, 2003.*)
79. R. Mills, J. He, B. Dhandapani, P. Ray, "Comparison of Catalysts and Microwave Plasma Sources of Vibrational Spectral Emission of Fractional-Rydberg-State Hydrogen Molecular Ion," Canadian Journal of Physics, submitted.
78. R. L. Mills, P. Ray, X. Chen, B. Dhandapani, "Vibrational Spectral Emission of Fractional-Principal-Quantum-Energy-Level Molecular Hydrogen", J. of the Physical Society of Japan, submitted. (*Web Publication Date: Sept. 9, 2002.*)
77. J. Phillips, R. L. Mills, X. Chen, "Water Bath Calorimetric Study of Excess Heat in 'Resonance Transfer' Plasmas," Journal of Applied Physics, submitted. (*Web Publication Date: June 16, 2003.*)
76. R. L. Mills, P. Ray, B. Dhandapani, X. Chen, "Comparison of Catalysts and Microwave Plasma Sources of Spectral Emission of Fractional-Principal-Quantum-Energy-Level Atomic and Molecular Hydrogen," Journal of Applied Spectroscopy, submitted. (*Web Publication Date: Feb. 12, 2002.*)
75. R. L. Mills, P. Ray, B. Dhandapani, J. He, "Novel Liquid-Nitrogen-Condensable Molecular Hydrogen Gas," Acta Physica Polonica A, submitted. (*Web Publication Date: Oct. 29, 2002.*)
74. R. L. Mills, P. C. Ray, R. M. Mayo, M. Nansteel, B. Dhandapani, J. Phillips, "Spectroscopic Study of Unique Line Broadening and Inversion in Low Pressure Microwave Generated Water Plasmas," Physics of Plasmas, submitted. (*Web Publication Date: June 18, 2003.*)
73. R. L. Mills, P. Ray, B. Dhandapani, J. He, "Energetic Helium-Hydrogen Plasma

164 ← no mention  
of Lyman's

Reaction," AIAA Journal, submitted. (Web Publication Date: July 26, 2002.)

72. R. L. Mills, M. Nansteel, P. C. Ray, "Bright Hydrogen-Light and Power Source due to a Resonant Energy Transfer with Strontium and Argon Ions," Vacuum, submitted.

sub. 71. R. L. Mills, P. Ray, B. Dhandapani, J. Dong, X. Chen, "Power Source Based on Helium-Plasma Catalysis of Atomic Hydrogen to Fractional Rydberg States," Contributions to Plasma Physics, submitted.

sub. 70. R. Mills, J. He, A. Echezuria, B Dhandapani, P. Ray, "Comparison of Catalysts and Plasma Sources of Vibrational Spectral Emission of Fractional-Rydberg-State Hydrogen Molecular Ion," European Journal of Physics D, submitted. (Web Publication Date: Sept. 2, 2002.)

→ 69. R. L. Mills, J. Sankar, A. Voigt, J. He, B. Dhandapani, "Spectroscopic Characterization of the Atomic Hydrogen Energies and Densities and Carbon Species During Helium-Hydrogen-Methane Plasma CVD Synthesis of Diamond Films," Chemistry of Materials, Vol. 15, (2003), pp. 1313-1321. (Web Publication Date: Dec. 31, 2002.)

XPS  
164

sub. 68. R. Mills, P. Ray, R. M. Mayo, "Stationary Inverted Balmer and Lyman Populations for a CW HI Water-Plasma Laser," IEEE Transactions on Plasma Science, submitted. (Web Publication Date: Aug. 16, 2002.)

164

→ 67. R. L. Mills, P. Ray, B. Dhandapani, J. He, "Extreme Ultraviolet Spectroscopy of Helium-Hydrogen Plasma," J. Phys. D, Vol. 36, (2003), pp. 1535-1542. (Web Publication Date: July 17, 2002.)

164  
substrate

EUV Spect.  $\mu$  wave on He + H

but novel lines observed could suggest  
of fractional method

sub. 66. R. L. Mills, P. Ray, "Spectroscopic Evidence for a Water-Plasma Laser," Europhysics Letters, submitted. (Web Publication Date: Sept. 19, 2002.)

$\mu$  wave

sub. 65. R. Mills, P. Ray, R. M. Mayo, "Spectroscopic Evidence for CW HI Lasing in a Water-Plasma," J. of Applied Physics, submitted. (Web Publication Date: Sept. 18, 2002.)

sub. 64. R. L. Mills, J. Sankar, A. Voigt, J. He, B. Dhandapani, "Low Power MPCVD of Diamond Films on Silicon Substrates," Journal of Vacuum Science & Technology A, submitted. (Web Publication Date: June 26, 2002.)

sub. 63. R. L. Mills, X. Chen, P. Ray, J. He, B. Dhandapani, "Plasma Power Source Based on a Catalytic Reaction of Atomic Hydrogen Measured by Water Bath Calorimetry," Thermochemica Acta, in press. (Web Publication Date: June 25, 2002.)

sub. 62. R. L. Mills, A. Voigt, B. Dhandapani, J. He, "Synthesis and Spectroscopic Identification of Lithium Chloro Hydride," Materials Characterization, submitted.

61. R. L. Mills, B. Dhandapani, J. He, "Highly Stable Amorphous Silicon Hydride," Solar Energy Materials & Solar Cells, in press. (Web Publication Date: April 15, 2002.)

sub. 60. R. L. Mills, J. Sankar, A. Voigt, J. He, B. Dhandapani, "Synthesis of HDLC Films from

Solid Carbon," Journal of Material Science, submitted. (Web Publication Date: May 3, 2002.)

→ 59. R. Mills, P. Ray, R. M. Mayo, "The Potential for a Hydrogen Water-Plasma Laser," Applied Physics Letters, Vol. 82, No. 11, (2003), pp. 1679-1681. (Web Publication Date: July 11, 2002.) *no mention*

58. R. L. Mills, "Classical Quantum Mechanics," Physics Essays, submitted. (Web Publication Date: May 23, 2002.) *CQM — to be read.*

57. R. L. Mills, P. Ray, "Spectroscopic Characterization of Stationary Inverted Lyman Populations and Free-Free and Bound-Free Emission of Lower-Energy State Hydride Ion Formed by a Catalytic Reaction of Atomic Hydrogen and Certain Group I Catalysts, Quantitative Spectroscopy and Radiative Transfer, No. 39, sciencedirect.com, April 17, (2003). *fractions quantum Nos. H lower E state*

→ 56. R. M. Mayo, R. Mills, "Direct Plasmadynamic Conversion of Plasma Thermal Power to Electricity for Microdistributed Power Applications," 40th Annual Power Sources Conference, Cherry Hill, NJ, June 10-13, (2002), pp. 1-4. (Web Publication Date: March 28, 2002.) *u wave*

55. R. Mills, P. Ray, R. M. Mayo, "Chemically-Generated Stationary Inverted Lyman Population for a CW HI Laser," European J of Phys. D, submitted. (Web Publication Date: April 22, 2002.)

→ 54. R. L. Mills, P. Ray, "Stationary Inverted Lyman Population Formed from Incandescently Heated Hydrogen Gas with Certain Catalysts," J. Phys. D, Applied Physics, Vol. 36, (2003), pp. 1504-1509. (Web Publication Date: March 20, 2002.)

53. R. Mills, "A Maxwellian Approach to Quantum Mechanics Explains the Nature of Free Electrons in Superfluid Helium," International Journal of Theoretical Physics, submitted. (Web Publication Date: June 4, 2002.)

→ 52. R. Mills and M. Nansteel, P. Ray, "Bright Hydrogen-Light Source due to a Resonant Energy Transfer with Strontium and Argon Ions," New Journal of Physics, Vol. 4, (2002), pp. 70.1-70.28. (Web Publication Date: October, 2002, when it became available on the New Journal of Physics website.)

→ 51. R. Mills, P. Ray, R. M. Mayo, "CW HI Laser Based on a Stationary Inverted Lyman Population Formed from Incandescently Heated Hydrogen Gas with Certain Group I Catalysts," IEEE Transactions on Plasma Science, Vol. 31, No. 2, (2003), pp. 236-247. (Web Publication Date: Feb. 4, 2002.)

→ 50. R. L. Mills, P. Ray, J. Dong, M. Nansteel, B. Dhandapani, J. He, "Spectral Emission of Fractional-Principal-Quantum-Energy-Level Atomic and Molecular Hydrogen," Vibrational

*novel lines observed*  
*EUV*  
*lower energy*  
*but fractional*



Spectroscopy, Vol. 31, No. 2, (2003), pp. 195–213.

- 49. R. L. Mills, P. Ray, E. Dayalan, B. Dhandapani, J. He, "Comparison of Excessive Balmer  $\alpha$  Line Broadening of Inductively and Capacitively Coupled RF, Microwave, and Glow Discharge Hydrogen Plasmas with Certain Catalysts," IEEE Transactions on Plasma Science, Vol. 31, No. 3, (2003), pp. 338–355. (*Web Publication Date: Sept. 17, 2002.*)
- 48. R. M. Mayo, R. Mills, M. Nansteel, "Direct Plasmadynamic Conversion of Plasma Thermal Power to Electricity," IEEE Transactions on Plasma Science, October, (2002), Vol. 30, No. 5, pp. 2066–2073. (*Web Publication Date: March 26, 2002.*)
- 47. H. Conrads, R. Mills, Th. Wrubel, "Emission in the Deep Vacuum Ultraviolet from a Plasma Formed by Incandescently Heating Hydrogen Gas with Trace Amounts of Potassium Carbonate," Plasma Sources Science and Technology, Vol. 12, (2003), pp. 389–395.
- Sub 46. R. L. Mills, P. Ray, "Stationary Inverted Lyman Population and a Very Stable Novel Hydride Formed by a Catalytic Reaction of Atomic Hydrogen and Certain Catalysts," Physica B, submitted.
- 45. R. L. Mills, J. He, P. Ray, B. Dhandapani, X. Chen, "Synthesis and Characterization of a Highly Stable Amorphous Silicon Hydride as the Product of a Catalytic Helium-Hydrogen Plasma Reaction," Int. J. Hydrogen Energy, Vol. 28, No. 12, (2003), pp. 1401–1424. (*Web Publication Date: April 15, 2002.*)
- Sub 44. R. L. Mills, A. Voigt, B. Dhandapani, J. He, "Synthesis and Characterization of Lithium Chloro Hydride," Int. J. Hydrogen Energy, submitted. (*Web Publication Date: Jan. 7, 2002.*)
- 43. R. L. Mills, P. Ray, "Substantial Changes in the Characteristics of a Microwave Plasma Due to Combining Argon and Hydrogen," New Journal of Physics, [www.njp.org](http://www.njp.org), Vol. 4, (2002), pp. 22.1–22.17. (*Web Publication Date: Dec. 27, 2001.*)
- 42. R. L. Mills, P. Ray, "A Comprehensive Study of Spectra of the Bound-Free Hyperfine Levels of Novel Hydride Ion  $H^-(1/2)$ , Hydrogen, Nitrogen, and Air," Int. J. Hydrogen Energy, Vol. 28, No. 8, (2003), pp. 825–871. (*Web Publication Date: Nov. 14, 2001.*)
- 41. R. L. Mills, E. Dayalan, "Novel Alkali and Alkaline Earth Hydrides for High Voltage and High Energy Density Batteries," Proceedings of the 17<sup>th</sup> Annual Battery Conference on Applications and Advances, California State University, Long Beach, CA, (January 15-18, 2002), pp. 1–6. (*Web Publication Date: Nov. 9, 2001.*)
- 40. R. M. Mayo, R. Mills, M. Nansteel, "On the Potential of Direct and MHD Conversion of Power from a Novel Plasma Source to Electricity for Microdistributed Power Applications," IEEE Transactions on Plasma Science, August, (2002), Vol. 30, No. 4, pp. 1568–1578.



(Web Publication Date: Nov. 12, 2001.)

39. R. Mills, P. C. Ray, R. M. Mayo, M. Nansteel, W. Good, P. Jansson, B. Dhandapani, J. He, "Stationary Inverted Lyman Populations and Free-Free and Bound-Free Emission of Lower-Energy State Hydride Ion Formed by an Exothermic Catalytic Reaction of Atomic Hydrogen and Certain Group I Catalysts," J. Phys. Chem. A, submitted. (Web Publication Date: Nov. 13, 2001.)
38. R. Mills, E. Dayalan, P. Ray, B. Dhandapani, J. He, "Highly Stable Novel Inorganic Hydrides from Aqueous Electrolysis and Plasma Electrolysis," Electrochimica Acta, Vol. 47, No. 24, (2002), pp. 3909–3926. (Web Publication Date: June 13, 2002.)
37. R. L. Mills, P. Ray, B. Dhandapani, R. M. Mayo, J. He, "Comparison of Excessive Balmer  $\alpha$  Line Broadening of Glow Discharge and Microwave Hydrogen Plasmas with Certain Catalysts," J. of Applied Physics, (2002), Vol. 92, No. 12, pp. 7008–7022. (Web Publication Date: Oct. 9, 2002.)
36. R. L. Mills, P. Ray, B. Dhandapani, J. He, "Emission Spectroscopic Identification of Fractional Rydberg States of Atomic Hydrogen Formed by a Catalytic Helium-Hydrogen Plasma Reaction," Vacuum, submitted. (Web Publication Date: Oct. 9, 2001.)
35. R. L. Mills, P. Ray, B. Dhandapani, M. Nansteel, X. Chen, J. He, "New Power Source from Fractional Rydberg States of Atomic Hydrogen," Current Appl. Phys., submitted. (Web Publication Date: Oct. 9, 2001.)
34. R. L. Mills, P. Ray, B. Dhandapani, M. Nansteel, X. Chen, J. He, "Spectroscopic Identification of Transitions of Fractional Rydberg States of Atomic Hydrogen," J. of Quantitative Spectroscopy and Radiative Transfer, in press. (Web Publication Date: Oct. 9, 2001.)
33. R. L. Mills, P. Ray, B. Dhandapani, M. Nansteel, X. Chen, J. He, "New Power Source from Fractional Quantum Energy Levels of Atomic Hydrogen that Surpasses Internal Combustion," J Mol. Struct., Vol. 643, No. 1-3, (2002), pp. 43–54. (Web Publication Date: Oct. 10, 2001.)
32. R. L. Mills, P. Ray, "Spectroscopic Identification of a Novel Catalytic Reaction of Rubidium Ion with Atomic Hydrogen and the Hydride Ion Product," Int. J. Hydrogen Energy, Vol. 27, No. 9, (2002), pp. 927–935. (Web Publication Date: Sept. 19, 2001.)
31. R. Mills, J. Dong, W. Good, P. Ray, J. He, B. Dhandapani, "Measurement of Energy Balances of Noble Gas-Hydrogen Discharge Plasmas Using Calvet Calorimetry," Int. J. Hydrogen Energy, Vol. 27, No. 9, (2002), pp. 967–978. (Web Publication Date: Sept. 14, 2001.)
30. R. L. Mills, A. Voigt, P. Ray, M. Nansteel, B. Dhandapani, "Measurement of Hydrogen

- Balmer Line Broadening and Thermal Power Balances of Noble Gas-Hydrogen Discharge Plasmas," *Int. J. Hydrogen Energy*, Vol. 27, No. 6, (2002), pp. 671–685. (*Web Publication Date: Aug. 22, 2001.*)
29. R. Mills, P. Ray, "Vibrational Spectral Emission of Fractional-Principal-Quantum-Energy-Level Hydrogen Molecular Ion," *Int. J. Hydrogen Energy*, Vol. 27, No. 5, (2002), pp. 533–564. (*Web Publication Date: July 19, 2001.*)
28. R. Mills, P. Ray, "Spectral Emission of Fractional Quantum Energy Levels of Atomic Hydrogen from a Helium-Hydrogen Plasma and the Implications for Dark Matter," *Int. J. Hydrogen Energy*, (2002), Vol. 27, No. 3, pp. 301–322. (*Web Publication Date: Aug. 1, 2001.*)
27. R. Mills, P. Ray, "Spectroscopic Identification of a Novel Catalytic Reaction of Potassium and Atomic Hydrogen and the Hydride Ion Product," *Int. J. Hydrogen Energy*, Vol. 27, No. 2, (2002), pp. 183–192. (*Web Publication Date: Jan. 11, 2002.*)
26. R. Mills, "BlackLight Power Technology-A New Clean Hydrogen Energy Source with the Potential for Direct Conversion to Electricity," *Proceedings of the National Hydrogen Association, 12 th Annual U.S. Hydrogen Meeting and Exposition, Hydrogen: The Common Thread*, The Washington Hilton and Towers, Washington DC, (March 6-8, 2001), pp. 671–697. (*Presented at the conference on March 7, 2001; Web Publication Date: April 20, 2001.*)
25. R. Mills, W. Good, A. Voigt, Jinqun Dong, "Minimum Heat of Formation of Potassium Iodo Hydride," *Int. J. Hydrogen Energy*, Vol. 26, No. 11, (2001), pp. 1199–1208. (*Web Publication Date: March 23, 2001.*)
24. R. Mills, "Spectroscopic Identification of a Novel Catalytic Reaction of Atomic Hydrogen and the Hydride Ion Product," *Int. J. Hydrogen Energy*, Vol. 26, No. 10, (2001), pp. 1041–1058. (*Web Publication Date: March 23, 2001.*)
23. R. Mills, N. Greenig, S. Hicks, "Optically Measured Power Balances of Glow Discharges of Mixtures of Argon, Hydrogen, and Potassium, Rubidium, Cesium, or Strontium Vapor," *Int. J. Hydrogen Energy*, Vol. 27, No. 6, (2002), pp. 651–670. (*Web Publication Date: July 20, 2001.*)
22. R. Mills, "The Grand Unified Theory of Classical Quantum Mechanics," Global Foundation, Inc. *Orbis Scientiae* entitled *The Role of Attractive and Repulsive Gravitational Forces in Cosmic Acceleration of Particles The Origin of the Cosmic Gamma Ray Bursts*, (29th Conference on High Energy Physics and Cosmology Since 1964) Dr. Behram N. Kursunoglu, Chairman, December 14-17, 2000, Lago Mar Resort, Fort Lauderdale, FL, Kluwer Academic/Plenum Publishers, New York, pp. 243–258.

*(Presented at the conference on Dec. 15, 2000; Web Publication Date: May 17, 2001.)*

21. R. Mills, "The Grand Unified Theory of Classical Quantum Mechanics," *Int. J. Hydrogen Energy*, Vol. 27, No. 5, (2002), pp. 565–590. *(Web Publication Date: Sept. 17, 2001.)*
20. R. Mills and M. Nansteel, P. Ray, "Argon-Hydrogen-Strontium Discharge Light Source," *IEEE Transactions on Plasma Science*, Vol. 30, No. 2, (2002), pp. 639–653. *(Web Publication Date: Dec. 7, 2000.)*
19. R. Mills, B. Dhandapani, M. Nansteel, J. He, A. Voigt, "Identification of Compounds Containing Novel Hydride Ions by Nuclear Magnetic Resonance Spectroscopy," *Int. J. Hydrogen Energy*, Vol. 26, No. 9, (2001), pp. 965–979. *(Web Publication Date: March 22, 2001.)*
18. R. Mills, "BlackLight Power Technology-A New Clean Energy Source with the Potential for Direct Conversion to Electricity," *Global Foundation International Conference on "Global Warming and Energy Policy,"* Dr. Behram N. Kursunoglu, Chairman, Fort Lauderdale, FL, November 26-28, 2000, Kluwer Academic/Plenum Publishers, New York, pp. 187–202. *(Presented at the conference on Nov. 26, 2000; Web Publication Date: Jan. 19, 2001.)*
17. R. Mills, "The Nature of Free Electrons in Superfluid Helium—a Test of Quantum Mechanics and a Basis to Review its Foundations and Make a Comparison to Classical Theory," *Int. J. Hydrogen Energy*, Vol. 26, No. 10, (2001), pp. 1059–1096. *(Web Publication Date: Dec. 11, 2000.)*
16. R. Mills, M. Nansteel, and Y. Lu, "Excessively Bright Hydrogen-Strontium Plasma Light Source Due to Energy Resonance of Strontium with Hydrogen," *J. of Plasma Physics*, Vol. 69, (2003), pp. 131–158. *(Web Publication Date: Aug. 27, 2001.)*
15. R. Mills, J. Dong, Y. Lu, "Observation of Extreme Ultraviolet Hydrogen Emission from Incandescently Heated Hydrogen Gas with Certain Catalysts," *Int. J. Hydrogen Energy*, Vol. 25, (2000), pp. 919–943. *(Web Publication Date: June 27, 2000.)*
14. R. Mills, "Observation of Extreme Ultraviolet Emission from Hydrogen-KI Plasmas Produced by a Hollow Cathode Discharge," *Int. J. Hydrogen Energy*, Vol. 26, No. 6, (2001), pp. 579–592. *(Web Publication Date: July 10, 2000.)*
13. R. Mills, "Temporal Behavior of Light-Emission in the Visible Spectral Range from a Ti-K<sub>2</sub>CO<sub>3</sub>-H-Cell," *Int. J. Hydrogen Energy*, Vol. 26, No. 4, (2001), pp. 327–332. *(Web Publication Date: July 10, 2000.)*
12. R. Mills, T. Onuma, and Y. Lu, "Formation of a Hydrogen Plasma from an Incandescently Heated Hydrogen-Catalyst Gas Mixture with an Anomalous Afterglow Duration," *Int. J. Hydrogen Energy*, Vol. 26, No. 7, July, (2001), pp. 749–762. *(Web Publication Date: June*

28, 2000.)

11. R. Mills, M. Nansteel, and Y. Lu, "Observation of Extreme Ultraviolet Hydrogen Emission from Incandescently Heated Hydrogen Gas with Strontium that Produced an Anomalous Optically Measured Power Balance," *Int. J. Hydrogen Energy*, Vol. 26, No. 4, (2001), pp. 309–326. (*Web Publication Date: June 27, 2000.*)
10. R. Mills, B. Dhandapani, N. Greenig, J. He, "Synthesis and Characterization of Potassium Iodo Hydride," *Int. J. of Hydrogen Energy*, Vol. 25, Issue 12, December, (2000), pp. 1185–1203. (*Web Publication Date: Nov. 12, 2001.*)
9. R. Mills, "Novel Inorganic Hydride," *Int. J. of Hydrogen Energy*, Vol. 25, (2000), pp. 669–683. (*Web Publication Date: June 28, 2000.*)
8. R. Mills, B. Dhandapani, M. Nansteel, J. He, T. Shannon, A. Echezuria, "Synthesis and Characterization of Novel Hydride Compounds," *Int. J. of Hydrogen Energy*, Vol. 26, No. 4, (2001), pp. 339–367. (*Web Publication Date: June 13, 2001.*)
7. R. Mills, "Highly Stable Novel Inorganic Hydrides," *Journal of New Materials for Electrochemical Systems*, Vol. 6, (2003), pp. 45–54. (*Web Publication Date: Nov. 20, 2001.*)
6. R. Mills, "Novel Hydrogen Compounds from a Potassium Carbonate Electrolytic Cell," *Fusion Technology*, Vol. 37, No. 2, March, (2000), pp. 157–182. (*Web Publication Date: June 26, 2000.*)
5. R. Mills, "The Hydrogen Atom Revisited," *Int. J. of Hydrogen Energy*, Vol. 25, Issue 12, December, (2000), pp. 1171–1183. (*Web Publication Date: June 27, 2000.*)
4. Mills, R., Good, W., "Fractional Quantum Energy Levels of Hydrogen," *Fusion Technology*, Vol. 28, No. 4, November, (1995), pp. 1697–1719. (*Web Publication Date: Nov. 1, 2001.*)
3. Mills, R., Good, W., Shaubach, R., "Dihydrino Molecule Identification," *Fusion Technology*, Vol. 25, 103 (1994). (*Web Publication Date: April 11, 2001.*)
2. R. Mills and S. Kneizys, *Fusion Technol.* Vol. 20, 65 (1991). (*Web Publication Date: April 11, 2001.*)
1. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, September 2001 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com; July 2003 Edition posted at [www.blacklightpower.com](http://www.blacklightpower.com).

### Book Publications

8. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 2003 Edition, BlackLight Power, Inc., Cranbury, New Jersey, posted at

[www.blacklightpower.com](http://www.blacklightpower.com).

7. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, September 2001 Edition, BlackLight Power, Inc., Cranbury, New Jersey, Distributed by Amazon.com.
6. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 2000 Edition, BlackLight Power, Inc., Cranbury, New Jersey
5. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, January 1999 Edition.
4. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, September 1996 Edition.
3. R. Mills, *The Grand Unified Theory of Classical Quantum Mechanics*, (1995), Technomic Publishing Company, Lancaster, PA provided by HydroCatalysis Power Corporation, Great Valley Corporate Center, 41 Great Valley Parkway, Malvern, PA 19355
2. R. Mills, *The Unification of Spacetime, the Forces, Matter, and Energy*, Technomic Publishing Company, Lancaster, PA, (1992).
1. R. Mills, J. Farrell, *The Grand Unified Theory*, Science Press, Ephrata, PA, (1990).